AIR ENGINEERING

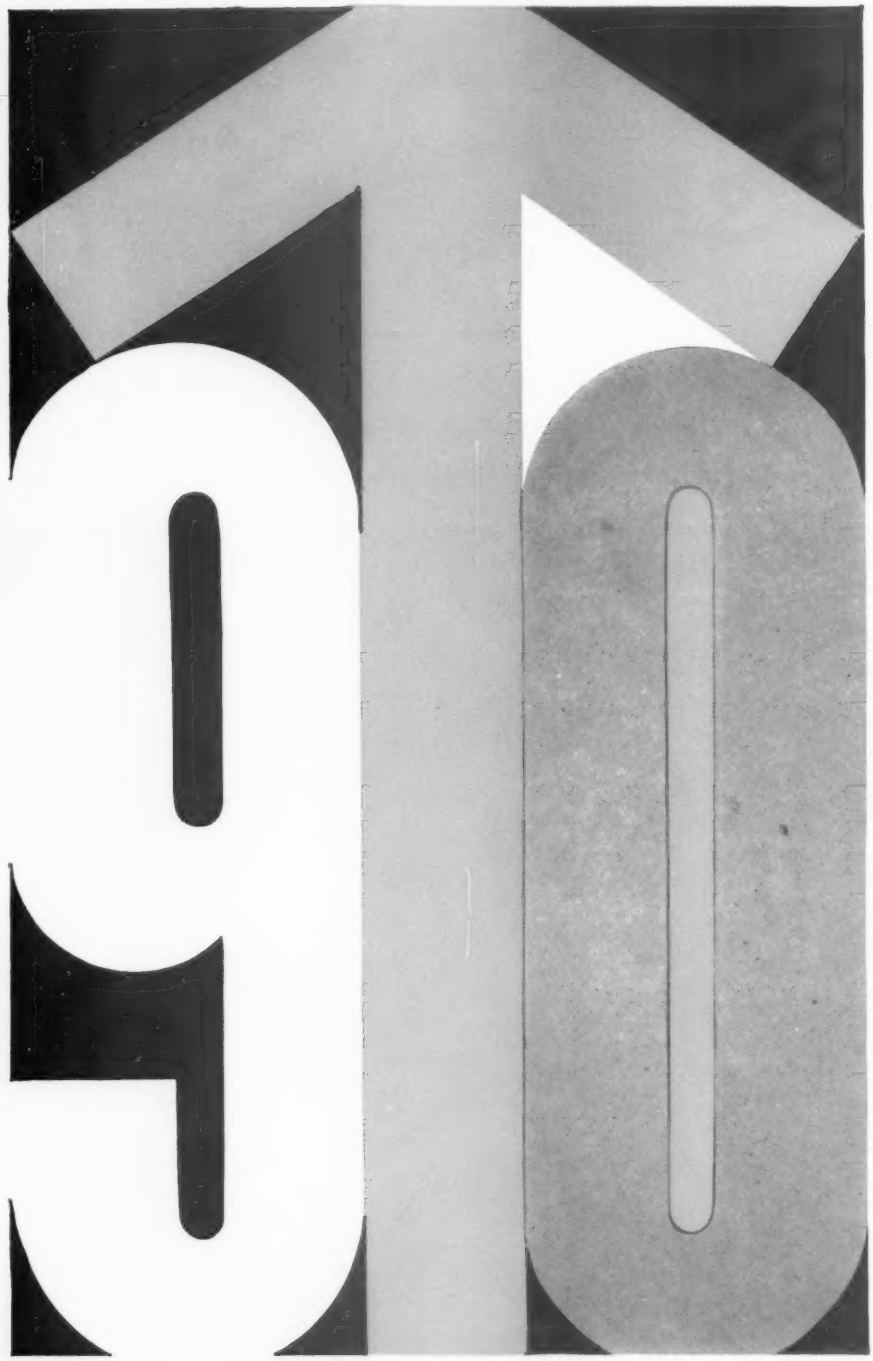
THE UNIVERSITY OF MICHIGAN
ENGINEERING LIBRARY

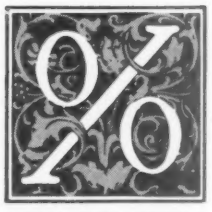
MARCH, 1961

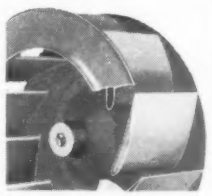
MAKING AIR COMFORTABLE, HEALTHFUL, SAFE, AND USEFUL FOR PEOPLE, PRODUCTS, PROCESSES

- ***How To Handle Corrosive Gases, Mists, Fumes***
- ***What You Should Know About Electrical Needs Of Precipitators***
- ***Sylvania Cools Factory, Ups Production 7 percent!***
- ***Six Ways To Ventilate Batch Dryers In Chemical Processing***

.0471 Per Manhour Cools This Mammoth Convair Plant - See P. 20







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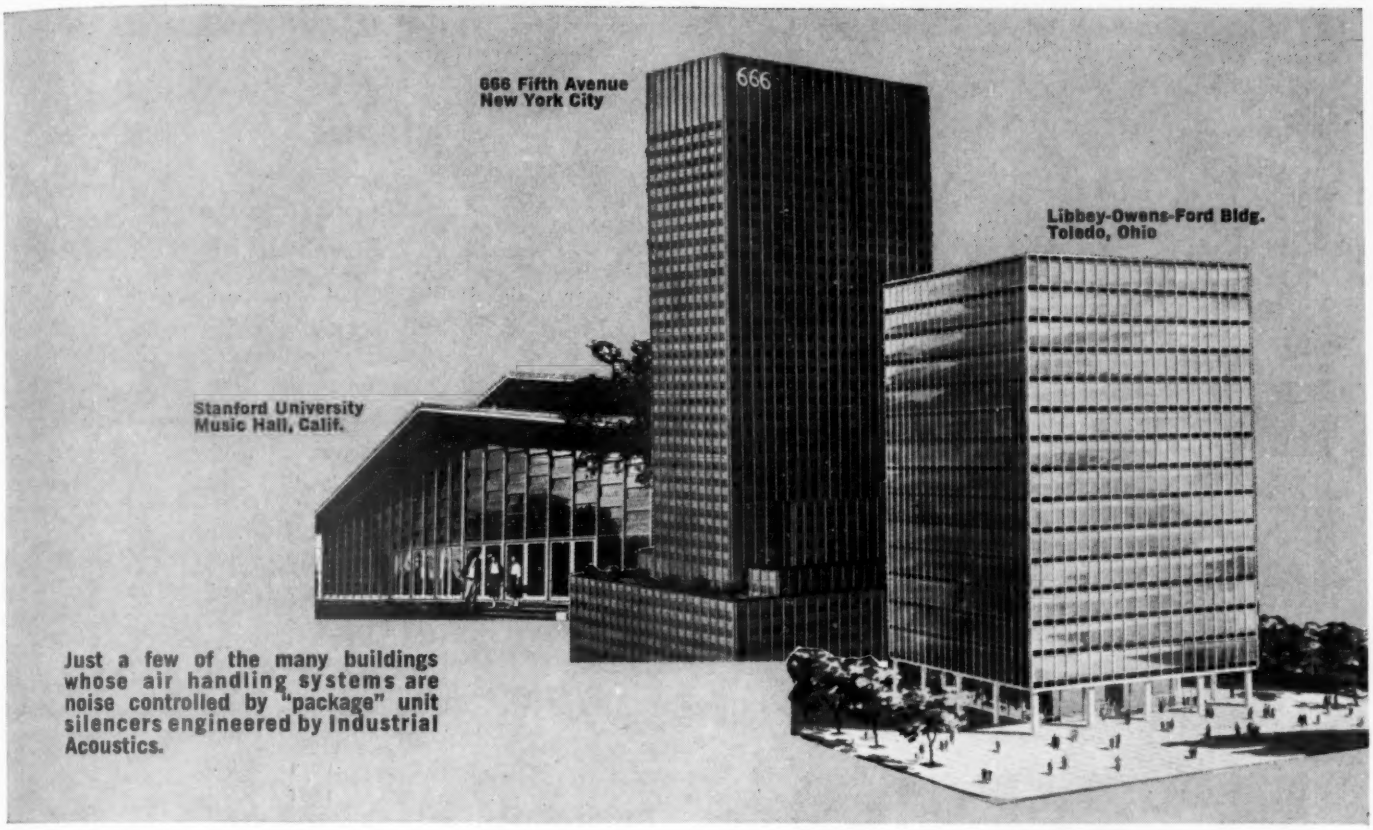

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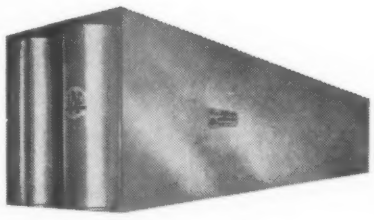

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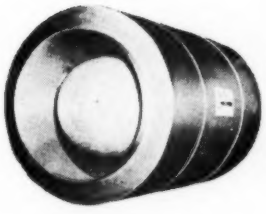

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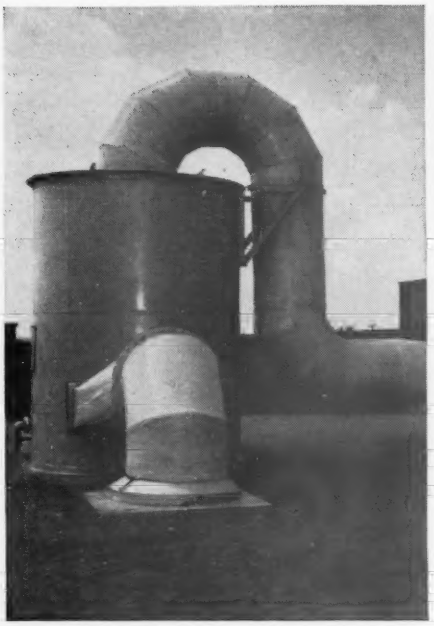
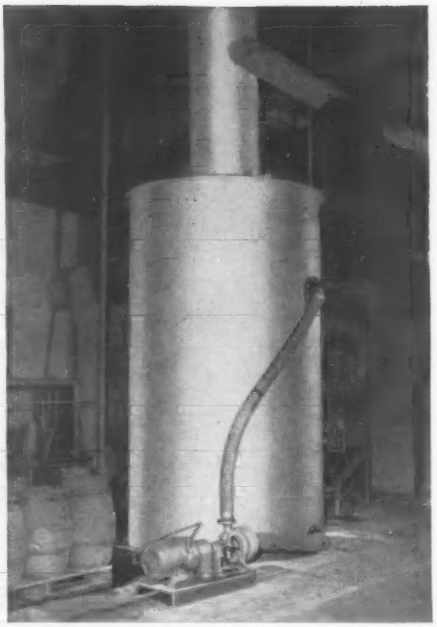


Heil Rigidon Plastic Fume Scrubber Neutralizing Mixed Acid Fumes.



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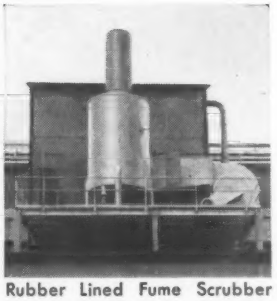

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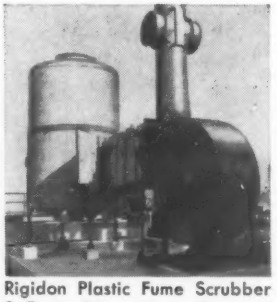

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Watch For These Articles Next Month!

✓ SUPER-CLEAN ROOMS FOR SUPER-CLEAN KLYSTRONS

by G. V. Freeman, Plant engineer, Litton Industries, Electronic Tube Div. Design, construction, air conditioning, ventilation of white rooms needed for assembly of close-tolerance electron tubes.

✓ POLLUTION-FREE INCINERATION OF HOSPITAL WASTES

by M. C. Larkin, Nash, Cadmus & Voelker, Inc. Factors involved in pollution-free and odorless burning of all types of hospital wastes.

✓ HOW SAFE IS YOUR INDUSTRIAL VENTILATION?

by E. M. Schmidt, Chief mechanical engineer, Engineering and Construction Dep't., Plant engineering, Ford Motor Co. Safety aspects of plant ventilation, design and use of roof ventilators, make-up air systems, air distribution and heating.

Use the Communications Center, page 51, to receive more information about any product advertised, any new literature or new product described. Circle the number on the postage-free card that refers to the item of your interest, add your name and address and mail.

To comment, criticize or make suggestions about any feature article in this issue, use the postage-free Editorial comment card.

Also listed in the Communications Center are reprints of articles from AIR ENGINEERING *and special reports. Circle the corresponding number to receive the reprint of your choice. If a price is listed, your bill will arrive with your reprint or you may enclose a check or money order.*

AIR ENGINEERING

VOL. 3, NO. 3

MARCH, 1961

MAKING AIR COMFORTABLE, HEALTHFUL, SAFE, AND USEFUL FOR PEOPLE, PRODUCTS, PROCESSES

FEATURES

Factory-wide Cooling For Only $.0471 Per Manhour! 20
by F. C. Clayton, chief plant engineer, Convair Div., General Dynamics Corp., Fort Worth, Texas. Cost study plus 18-years' maintenance experience.

How To Handle Corrosive Gases 26
by Frank J. Versagi. Primer on which plastic material to use for what corrosive gas, fume or mist.

Electrical Requirements of Electrostatic Precipitators 31
by L. L. Nagel, chief electrical engineer, Buell Engineering Co., Inc. How specs for precipitators affect electrical requirements.

Sylvania Gets More Production, Less Absenteeism, From Factory Cooling 34
by E. A. Sloane. Tells of 30% investment return, 7% more production, 50% less absenteeism, attributed to plant air conditioning.

Plastic Fibers As Panel Filter Media 37
by Air Filter Institute. Challenges efficiency of fiber filters if based on electrostatic effect.

Ventilation of Dry Batch Chemical Production 38
by William V. Andresen, chief industrial hygienist, American Cyanamid Co. Hood design, duct layout, air flow requirements.

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COVER

Cover shows inside of one of main assembly bays of Convair plant at Fort Worth, Texas, one of country's first air conditioned, windowless plants. See page 20 for story on this plant.

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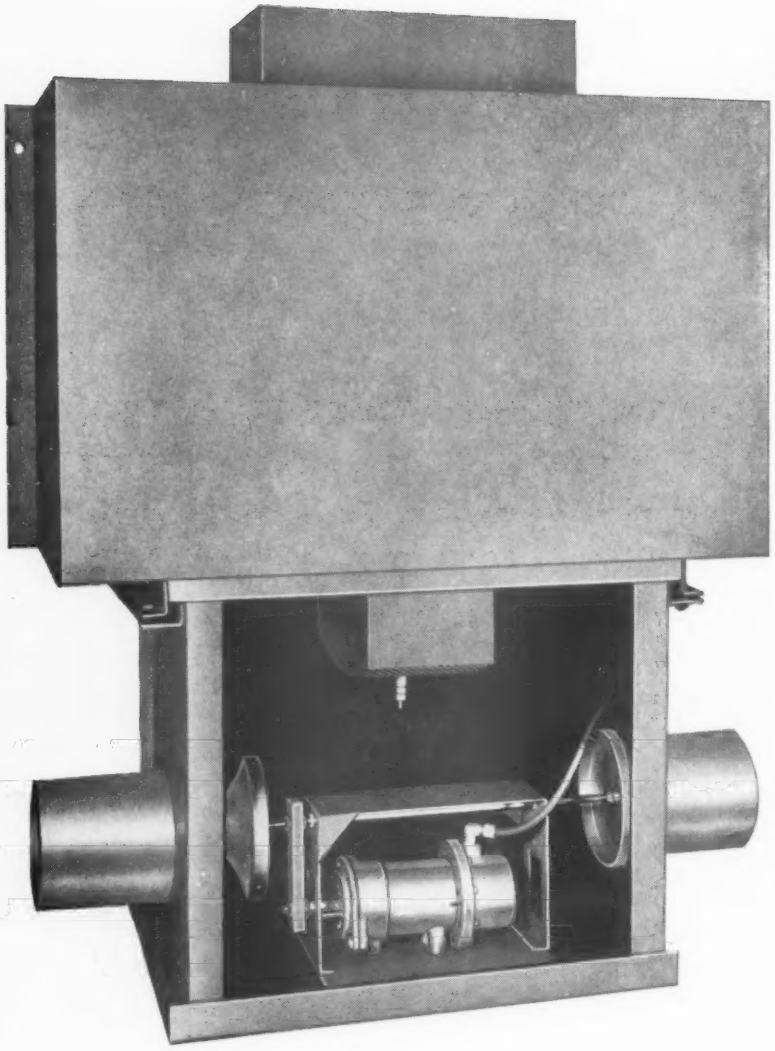

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Letters

Question on Ultra-Violet Article

Editor:

A question was raised by Mr. R. T. Tamblyn of R. T. Tamblyn and Partners, Ltd., Toronto 7, Ontario, regarding the calculations on page 33 of your October issue, which are part of the article on Air Sanitation with Ultraviolet Light. "It (was) not obvious why the length of duct should have a bearing on the sterilization of air passing through."

The length of the duct as well as the height and width have a bearing on the number of airborne organisms destroyed. Let us, for example, assume a duct 36″ x 36″ x 120″ long with an airflow of 600 ft/min. The ultraviolet lamp would be mounted in the middle of the duct perpendicular to the airflow. An airborne organism entering such a duct would be exposed for a total of 1 second, 0.5 second approaching the lamps and 0.5 second going away from the lamps. The amount of energy intercepted by the organism would be the integrated intensity along the length of the duct multiplied by the time. Most of the ultraviolet energy intercepted by the walls and ends of the duct is absorbed and is no longer available to destroy bacteria.

Now let us assume that the duct is only 60 inches long. The organism in the short duct will be exposed for only half of the time as previously. However, the total energy intercepted by the organism will be approximately 75 percent of the energy the organism was exposed to in the longer duct. Thus the ultraviolet energy in the large duct is more efficiently used.

The values in Figure 4 were obtained by first making bacteriological tests in a duct where we could vary a number of the parameters. Then, calculations were made for other sizes of ducts to give a 90 percent disinfection of air assuming a vulnerability similar to *E. coli*. Thus the V.D.W. (volume of air disinfected per watt of 2537 A radiation) in the formula is a measure of efficiency of the radiation in different sized ducts.

R. Nagy, Ph.D.
Research Dept.
Lamp Division
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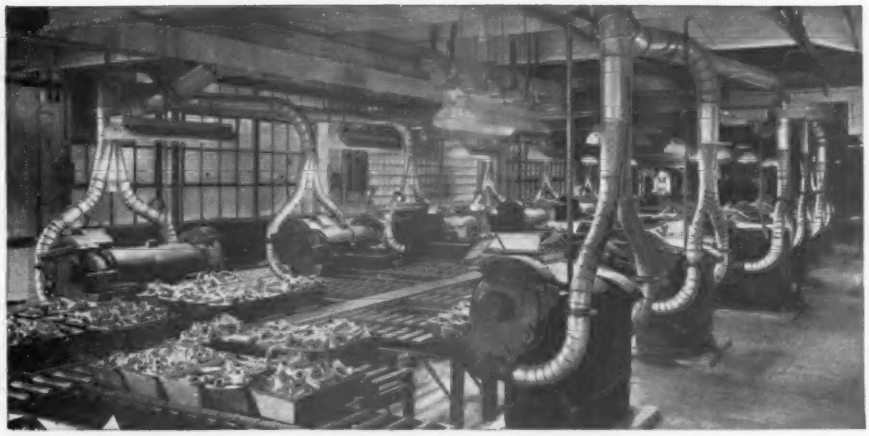

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Letters

CEC Praises December Editorial

Editor:

We have received from your Assistant Editor copies of recent issues of AIR ENGINEERING. It is indeed a handsome publication, and we were particularly pleased to note your editorial policy as expressed in the December, 1960 editorial entitled "An Open Letter To Owners . . . For Engineers."

It goes without saying that Consulting Engineers Council endorses fully the viewpoint expressed by AIR ENGINEERING on this particular subject, and heartily commends your publication for its forthrightness in taking what architect readers may consider a very unpopular stand.

If tear sheets of the December editorial are available, we could use upwards of one dozen to distribute to officers and other interested organizations. Also, should an opportunity develop to republish the editorial (with proper credit, of course, to AIR ENGINEERING) in our CEC "Newsletter," may we have your permission to do so?

Once again, thanks for the kind words. Please advise your Circulation Manager to add our name to your subscription list and to bill us accordingly.

Larry N. Spiller
Executive Secretary
Consulting Engineers Council
Springfield, Illinois

Editor:

Your editorial, "An Open Letter To Owners . . . For Engineers," appearing in the December issue of AIR ENGINEERING was read and noted with interest. In a world geared to speed and action with provisions for a "fall guy" in case judgment is erroneous, your editorial certainly puts faith back into performance, ability, and creative thinking.

Although my particular specialty field is Sanitary Engineering, I am confronted with many of the problems intimated in your

(Please turn to page 10)

AIR ENGINEERING

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EDITORIAL:

The Danger Of Making Assumptions . . .

AN ASSUMPTION, says Webster's Unabridged dictionary, is the "act of taking for granted or supposing without proof, that a thing is true."

This department assumed, for example, that because of an airline tie-up, attendance at the 10th Annual Industrial Ventilation Conference, held at East Lansing, Michigan, Feb. 20-23, would be sparse.

We are happy to report that attendance was not far below normal, and that over 200 air engineers thought enough of the need for more education in industrial ventilation to travel, many by car, from as far away as Utah, Montana, Colorado, Masschusetts, and Rhode Island, despite travel hardships.

Our assumption having been proved in error, we wonder how many assumptions are made that are also wrong, or partly so, to the detriment of our industry?

For example, during a question and answer bull session at this Michigan State University sponsored ventilation conference, the question was posed: "How do you make high velocity systems work?" Since high velocity systems have existed since 1932, we wonder whether people who make equipment for such systems or who design such systems aren't assuming too much knowledge on the part of the people for whom this equipment is made or these systems designed?

Pursuing this subject further, we found some recent high velocity systems have been installed with straight duct take-offs, sans transitions, with consequent loss of fan and air distribution efficiency. We wonder if some equipment manufacturer's sales engineer assumed, in these cases, that the customer knew how to design high velocity air distribution systems? This could be a fatal assumption, because the customer is most likely going to blame any trouble on equipment and not on the system *he* designed.

At this same bull session many questions were asked about plant make-up air. The words published about make-up air problems and how to solve them must run into the millions (including those we've

(Please turn to following page)

Editorial (Cont.)

(Continued from preceding page)

published). Yet we *know* that many plant managers tolerate dangerous make-up air conditions. Do people who make equipment that can be used for make-up air, assume that because make-up air problems have long since been solved, there's little market for this equipment? We hope not, for such an assumption in the face of the evidence to the contrary, would be wrong.

From the Ventilation Conference comes the question: "How do you balance air distribution systems?" Which brings up another assumption: Should the consulting engineer forget about checking out system balance, on the assumption that the mechanical contractor knows how to do this? If the consulting engineer is responsible to the owner or architect for system performance, such an assumption could be dangerous for him.

Then there's the case of the highly toxic substance toluenediisocyanate. This stuff is used in manufacture of polyurethane foams, is dangerous and needs special ventilation attention. It's been in use for four or five years, at least, and the methods of ventilating it have long since been established.

Yet the people who make TDI apparently assume that because they publish its toxicity on the label, and because it's been on the market for some time, that all further attention as to how the user uses it can be forgotten. Again, at this Conference, as at previous Conferences, came questions about TDI ventilation.

Lest anyone assume that because blowers and fans have been used to push air around for many years, that standards of noise levels have been established by now, let us say that this would be a false assumption.

At the Ventilation Conference the question: "Have standards been established for rating noise levels on industrial fans?" was answered "Not yet." The Air Moving and Conditioning Association, the industry watchdog of fan performance ratings, is laudably getting fan manufacturers to agree about such ratings, and they are on the way.

One of the first cases of beryllium poisoning came up in the early 1930's and since that time many more such cases, the reasons therefore, and the ventilation remedies thereof, have been established. We've run a series of articles on the subject. Yet, because non-magnetic and non-sparking beryllium gears, tools and components are playing new roles in modern American industry, people are still having beryllium ventilation problems. At the Michigan Industrial Ventilation Conference quite a few people from industry wanted to know how to ventilate beryllium dusts, fumes, fines.

We in the business of air engineering must therefore never assume that because air engineering problems have been solved they are ended forever. The role of publications like AIR ENGINEERING is to find out what problems are currently plaguing air engineers and to bring solutions to their attention, even though these solutions are not necessarily new or even novel. ▲▲

Eugene A. Sloane

Editor

Meetings, Courses, Expositions

3rd Annual Industrial Ventilation Conference, *North Carolina State College, Raleigh, N. C., March 20-23, 1961.*

11th Annual ISA Conference on Instrumentation for the Iron & Steel Industry, *Roosevelt Hotel, Pittsburgh, March 8-10, 1961.*

National Assn. of Corrosion Engineers (annual conference and Corrosion Show), *Statler hotel, Buffalo, N. Y., March 13-17, 1961.*

139th Annual American Chemical Society, *St. Louis, Missouri, March 21-30, 1961.*

National Assn. of Refrigerated Warehouses, Inc. and The Refrigeration Research Foundation, *Mark Hopkins Hotel, San Francisco, Calif., March 27-30, 1961.*

3rd Symposium on Temperature—Its Measurement and Control in Science and Industry, *Veteran's Memorial Hall, Columbus, Ohio, March 27-31, 1961.*

Gas Appliance Manufacturers Assn., *Boca Raton Hotel, Boca Raton, Florida, April 5-7, 1961.*

American Industrial Hygiene Conference, *Sheraton-Cadillac Hotel, Detroit, April 10-13, 1961.*

7th National ISA Symposium on Instrumental Methods of Analysis, *Shamrock-Hilton Hotel, Houston, Texas, April 17-19, 1961.*

39th Annual Convention of the Oil Heat Institute of America, *Statler-Hilton, Washington, D. C., April 23-27, 1961.*

National Assn. of Electrical Distributors (annual convention), *Detroit, April 29-May 3, 1961.*

Consulting Engineers Council, *Chicago, Illinois, May 4-6, 1961.*

4th National ISA Power Instrumentation Symposium, *LaSalle Hotel, Chicago, May 8-10, 1961.*

12th Annual National Conference of the American Institute of Industrial Engineers, *Sheraton Cadillac, Detroit, May 11-13, 1961.*

Industrial Heating Equipment Association, Inc., *The Homestead, Hot Springs, Virginia, May 21-24, 1961.*

Air Pollution Instrumentation Symposium, *Hotel Commodore, New York, June 12, 1961.*

Electrical Precipitation Seminar, *The Pennsylvania State University, University Park, Pennsylvania, June 12-17, 1961.*

Ultimately, *somebody* has to get rid of "plant" dust, dirt, smoke and fumes. If the job is left up to workers, the cost to management is exorbitant. For example, if workers' cars are constantly exposed to blankets of dust in the Company parking lot, lowered morale and complaints are the inevitable result.

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Letters

(Continued from page 6)

editorial and can say that your analysis of the problem is applicable to other fields where more than one branch must apply talents to a finished product.

May I congratulate you on your foresightedness and your courage to state the facts as they really are.

George J. Toman
Secretary
Consulting Engineers Council
Handen, North Dakota

Likes "White Room" Data

Editor:

Thank you for the revised and corrected listing of your "Directory of Supplies and Equipment for White Rooms."

In connection with the general topic of White Rooms, I want to compliment the staff of your magazine for the excellent job they have done in the December issue. The growth of your magazine in the past two years has been little short of phenomenal. The general scope of your articles and the down to earth context thereof, result in interesting, informative reading. Yours is the only magazine that I know of, that has taken the White Room situation by the ears, and is making an all out constructive effort to coordinate the thinking of the major men engaged in this field.

Again, many thanks.

C. E. Schmid
Manager Plant Engineering and Facilities
Kearfott Division
General Precision, Inc.
Little Falls, New Jersey

For more information on any product advertised or mentioned in AIR ENGINEERING, *or to comment on editorial material, use the convenient postage-free cards on page 51.*

Picture In AIR ENGINEERING Results In Orders

Editor:

In the December 1960 issue of AIR ENGINEERING a picture of a Clean Room Area Entrance is shown on page 41. This photo shows the Clean-Tread or Sticky Mat that we manufacture.

I wonder if it is possible to get extra copies of this photo. You may also be pleased to know that as the result of this photo appearing, we have received many orders and requests for information.

Samuel D. Caplan
President
Merit Paper & Chemical Corp.
Cambridge, Massachusetts

"The Importance Of Make-Up Air"

Editor:

In addition to the obvious benefits of make-up air mentioned in your January editorial, "The Importance Of Make-Up Air," there is one other—less tangible but extremely important. This the physiological benefit of controlling working spaces at a high constant absolute pressure of about 30 in. Hg, regardless of outdoor conditions.

Medical research has shown that workers have a healthier mental outlook and produce more with less fatigue under such conditions. While still not widely recognized in the ventilating field, it should be brought to the attention of more architects and engineers for consideration in achieving maximum benefits in ventilated working spaces.

W. E. Wendover
American - Standard
Industrial Division
Detroit, Michigan

New White Room Association Grows

Editor:

In the December issue we noted the report on the White Room Symposium, and the formation of the American Association for Control of Super-Clean Areas.

Speaking for myself, as well as my Engineering Staff, I would like

(Please turn to third cover)

the CLOSED door that's always OPEN

HOPPER PAPER COMPANY, TAYLORVILLE, ILLINOIS. Fire extinguisher fumes, simulating wind, are unable to penetrate the American Air Curtain

A barrier to wind and weather, heat and cold, odors and insects—the gentle curtain of air seals off areas of different temperatures, atmospheric pressures or humidities. Dust and fumes from industrial operations are confined to their own areas, but even the heaviest traffic moves easily...safely. Let us show you how an American Air Curtain can mean increased efficiency in *your* plant.

PEOPLE AND PRODUCTS MOVE THROUGH THE CLOSED DOOR THAT'S ALWAYS OPEN

AMERICAN AIR CURTAIN
A DIVISION OF UNIVERSAL MATCH CORPORATION
ST. LOUIS 35, MISSOURI

NEWS of the Industry

Figure 1

Figure 2

Figure 3

10th Annual Ventilation Conference A Success

Despite the hardships of an airline strike, some 200 air engineers showed up at the 10th Annual Ventilation Conference at Michigan State University last month.

Attendance was down from previous years about 20 percent, and would have been down further except for those intrepid engineers who drove from Rhode Island and other difficult-to-get-from places to E. Lansing, Mich., for the Conference.

In the accompanying photos, Fig. 1 shows, at left, William Appledoorn, sales department engineer, at right, Norman Melzer, Manager, industrial fan department, Clarage Fan Company, at their interesting lucite fan demonstration rig.

Fig. 2 shows James C. Barrett, Ventilation Engineer, Division of Occupational Health, Michigan Department of Health, demonstrating what happens with good and with poor duct design.

Fig. 3 shows part of the audience of some 200 air engineers attending the conference, at one of the demonstration lectures. Students also studied theory in small, intensive classroom sessions.

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A handy, pocket-size device, designed by our engineers to make life easier for you. Complicated computations are eliminated. At a glance you see the type and size Morse Boulger Incinerator Unit required for your specific job.

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Air Pollution Control Association

AIHA To Hold National Conference In Detroit, April 9-13, 1961

The American Industrial Hygiene Association will hold its national conference in Detroit, at the Sheraton-Cadillac Hotel, April 9th-13th.

As a special feature of the Conference, Refresher Courses will be taught. These are teaching sessions designed to bring the participants up to date on specific techniques of industrial hygiene, or to provide instruction for those who lack personal experience in certain fields.

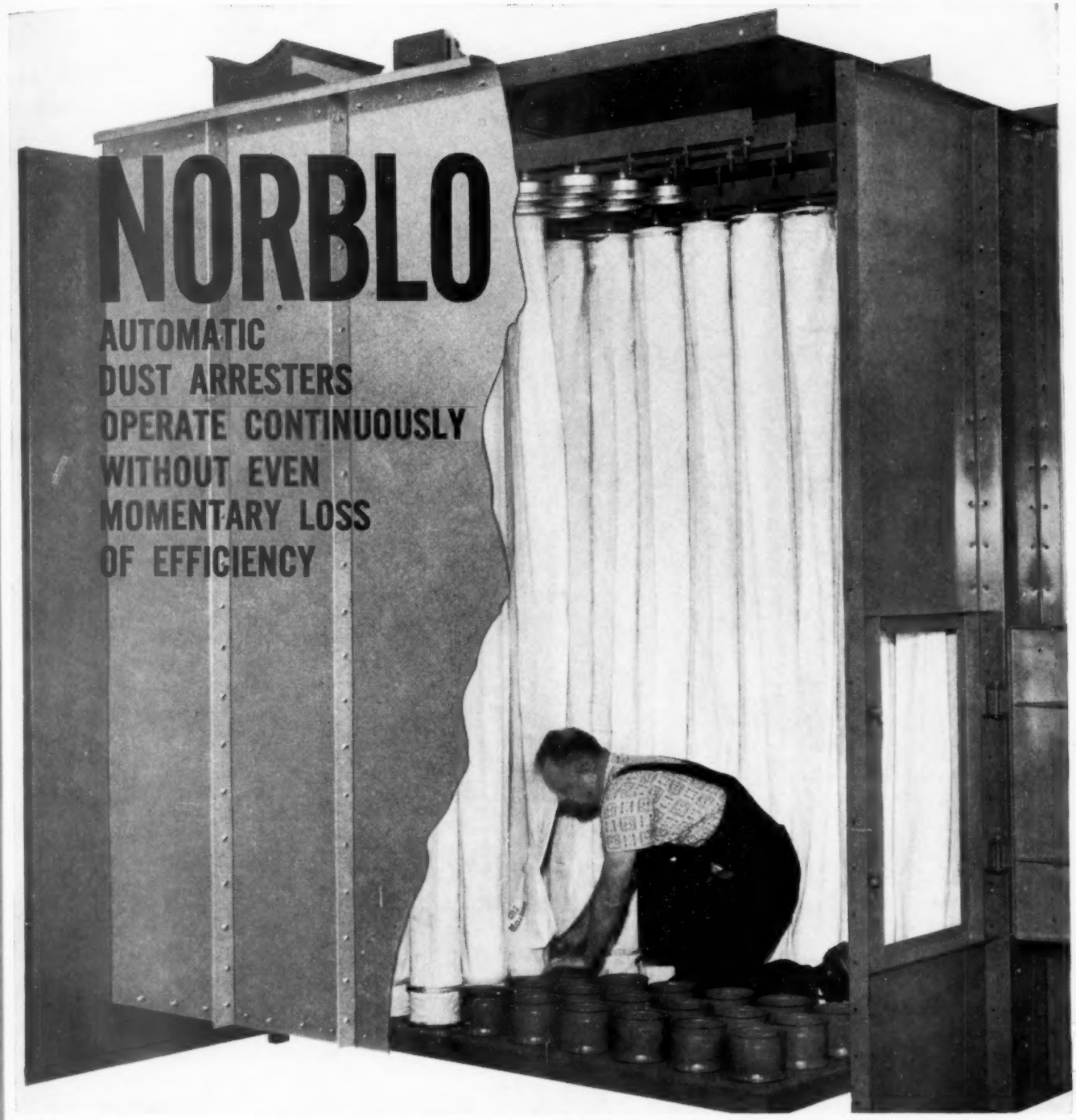
Each Refresher Course will be limited to approximately 20 registrants. Registration should be made in advance, by mail, they will be recorded in order of their receipt. The fee is $2.00 per course and each course will be 1 hour.

Monday, April 10th the refresher courses will be given, to include: Dust Counting With The Phase Microscope; Importance Of Isokinetic Sampling And How To Achieve It; Industrial Noise Measurement; How To Calibrate A Swinging Vane Anemometer; Permissible Dose For Internal Radiation; Radiated Heat Measurement And Calculation; The Language Of Industrial Toxicology; Identification Of Solvent Mixtures; and Theory And Use Of Pitot Tube.

Also on Monday will be the opening general session, which will include a discussion of Industrial Hygiene Objectives In Industry, Labor, Government, And Education.

Tuesday, Wednesday, and Thursday, April 11, 12, and 13th will be

(Please turn to page 14)



Periodic cleaning, repair or replacement of bags, and minor maintenance can be accomplished while the collector remains in operation. One compartment, as shown above, can be isolated in the Norblo design, with all mechanical parts outside the gas stream. Continuous cyclic shaking, by compartment, allows operation without interruption. ■ This is why in modern plant operations you'll find an increasing preference for Norblo Automatic Bag Arresters. Where efficient production requires continuous operation more and more industries specify Norblo Dust Arresters. Over 80% of the cement industry relies on Norblo equipment for drying, grinding and finishing operations. ■ Buell-Norblo equipment can play an essential part in your process. Write for complete information on any type of dust collection problem. Buell Engineering Company, Inc., Dept. 62-C, 123 William Street, New York 38, New York. Northern Blower Division, 6417 Barberton Avenue, Cleveland, Ohio. Electric Precipitators · Cyclones · Bag Collectors · Combination Systems · Fans · Classifiers.

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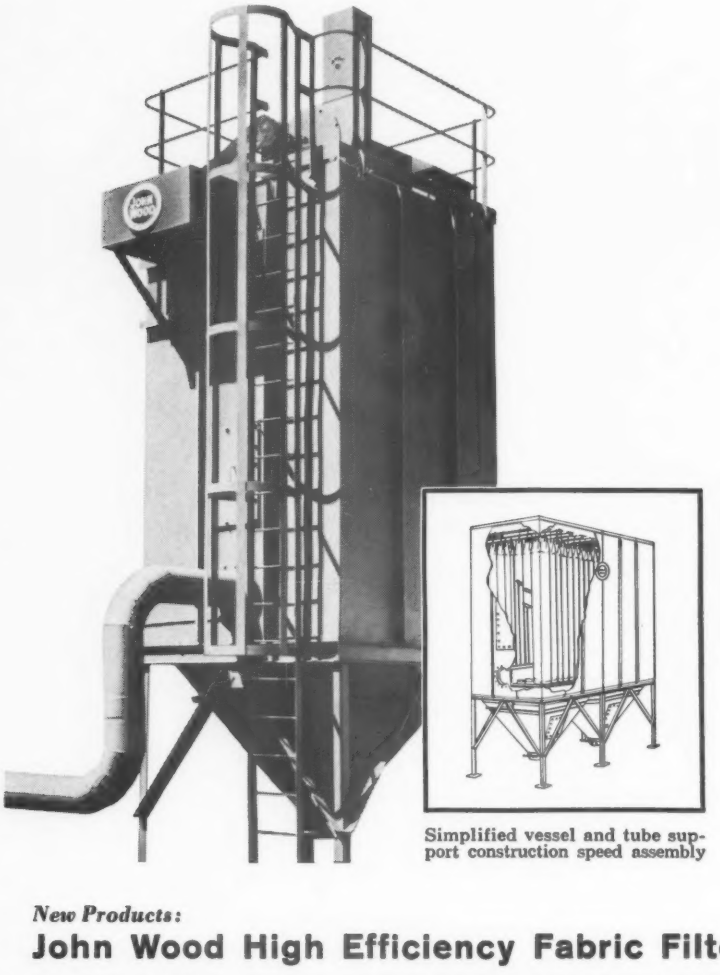
New Ideas On Dust And Fume Control



Simplified vessel and tube support construction speed assembly

New Products:

John Wood High Efficiency Fabric Filter

John Wood Fabric Filters are engineered for 99.9% efficiency in addition to trouble-free operation. They are the result of a program to design equipment for fully effective removal of all dry dusts at elevated operating temperatures.

An extremely varied group of filter sizes, shapes and types is available in capacities from 100 CFM to 48,000 CFM. Larger volumes are handled through a combination of units. John Wood automatic reverse flow mechanisms or shaker assemblies assure proper and gentle cleaning of fabric. Tubular or envelope bags are made of cotton, orlon, dacron, nylon or glass to meet any requirement.

New Engineering: John Wood Fabric Filters are but part of the complete line. Other equipment includes Interphase Reaction Scrubbers, Multi Cyclones, Involute Cyclones, Venturi Scrubbers and combination units. New designs are now under development.

New Service: John Wood Air Pollution Control is fully programmed from analysis of existing conditions to equipment installation. Frequently economies result that make the installation self-liquidating through lower maintenance and replacement costs.

Write for engineering assistance or specific product information. An air pollution preliminary analysis kit is available without obligation.

AIR POLLUTION CONTROL DIVISION
JOHN WOOD COMPANY
6 NICOLET AVENUE FLORHAM PARK, N. J. TUcker 7-3200

NEWS

(Continued from page 12)

concurrent sessions on Chemical and Analytical Determination, Engineering, Noise, General Medical, Session AIHA and ACGIH, Air Pollution, Radiation, Toxicology, and Medical Sessions.

A wide range of Commercial and Scientific Exhibits will be open the 11th, 12th, and 13th.

To receive the Conference Program, register for a Refresher Course, or for more information, contact George Clayton, AIHA Executive Secretary, 14125 Prevost, Detroit 27, Michigan.

Schools Experiment With Electric Heat

The Detroit Board of Education approved an experiment in the use of electricity for heating schools.

The board authorized Supt. Samuel M. Brownell to negotiate a 10-year contract with the Public Lighting Commission for electricity to heat two or three new schools.

The PLC has agreed to provide electricity at a sharply reduced rate during the experimental phase "so that costs for operating and maintenance will be no higher than if schools were heated by coal," Brownell said.

A PLC representative told the board it would be charged only 1.029 cents a kilowatt-hour to start. This is nearly a third of a cent under what it now pays for PLC service for lighting and more than a half-cent under regular electric rates.

An increasing number of new suburban schools are being equipped with electric heating systems, even though electricity as a fuel is considerably more expensive than coal or oil, it was reported.

Brownell said the use of electricity offers enough advantages to merit limited installation on a trial basis.

Advocates of electric heat say that an electrical system is cheaper to install, makes it possible to devote more of the building space to classrooms, is more flexible, and cuts down on operating personnel.

Ventilation Confab To Be March 20-23

The 3rd Annual Industrial Ventilation Conference to be held March 20-23, 1961, at the North Carolina State College, Raleigh, N.C., is a 3½-day workshop to present design information and practical solutions for better air handling.

Engineers, contractors, and others concerned with good ventilation will find the conference a place for the exchange of ideas and up-to-date information. Design problems will be offered for both the beginning and advanced designer of industrial ventilation systems.

The tuition fee is $40.00 and includes the Industrial Ventilation Manual, and the March 22nd banquet and final luncheon.

Some of the subjects to be discussed at the conference are: Exhaust Systems; Discussion of Design Problems; Evaporative Cooling For Air; Dust Collectors; Fan Performance Demonstration; and Hood Design, Capture, and Carrying Velocities.

For more information write the College Extension Division, P.O. Box 5125, State College Station, Raleigh, North Carolina.

N. Y. Asks $781,810 For Air Pollution Control

The New York City Department of Air Pollution Control is asking for a budget of $781,810 for the 1961-1962 fiscal year, an increase of $47,460 over the amount appropriated for the current fiscal year.

Commissioner Arthur J. Benline told the Director of the Budget: "We are hopeful that the administration of the City of New York will acknowledge—by monetary action—that air pollution is a problem of grave concern to our citizens and that something more must be done about it than has been done. We believe—as we and others have stated many times before—that the people of this City are ready and willing to pay for full-time, hard-hitting, and well-supported air pollution control. The question is: are we willing to give the people what they want and must have?"

(Please turn to following page)

No More BLACK HALOES

in Detroit's Beautiful City-County Building

Since the installation of the Cambridge AEROSOLVE® 85 filters – which *do* remove the invisible, smudge-producing particles – the 504,000 c.f.m. of air circulating through the City-County Building is *really clean*. Equipped with prefilters, the 280 cartridges in this AEROSOLVE filter bank have a service life of more than a year.

Combine Filter Efficiency with Filter Economy on Your Next Job

Write for Bulletin 132

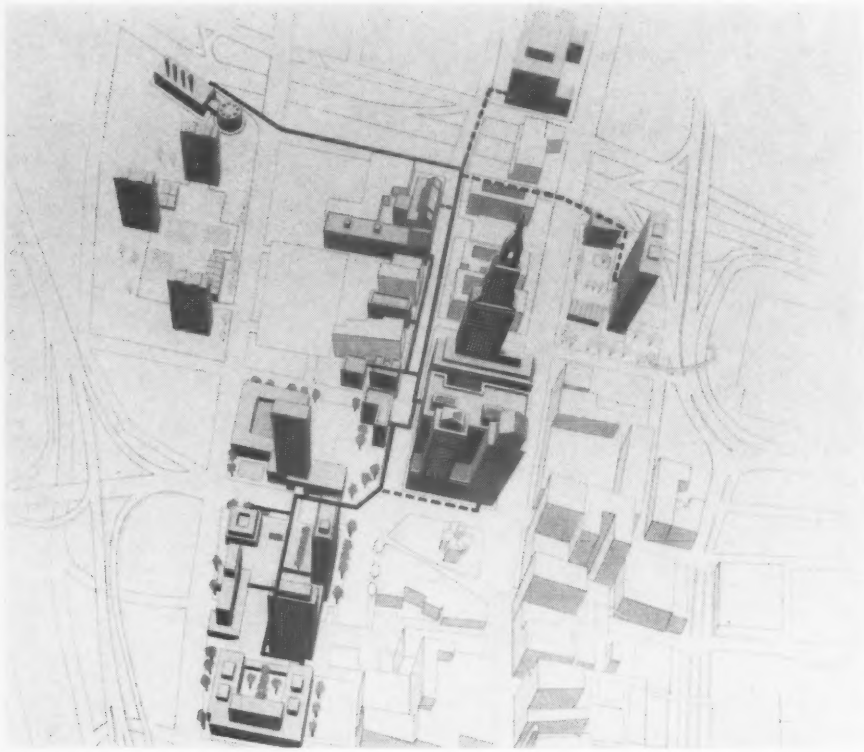
Here's where the "haloes" are trapped. Note how easily AEROSOLVE cartridges are replaced.

Cambridge® Filter Corporation

744 East Erie Boulevard, Syracuse 1, N.Y.

NEWS of the Industry . . .

(Continued from preceding page)



Urban Construction Expands Air Conditioning Market

Twenty-five cities throughout the United States and Canada constitute a total of over 2½ billion dollars being spent for urban renewal and construction . . . which offers a wide potential market for air conditioning.

Current urban constructions projects include: Baltimore, Md., $127-million for Charles Center Project; Boston, Mass. a total of $310-million; Houston, Texas, $100-million for Cullen Center; Indianapolis, Ind., $100-million redevelopment program; Los Angeles, $315-million, 136 acre renewal project; Newark, N.J., a total of $295-million; New York City, 10 projects involving 20,295 apartments, plus $250-million World Trade Center and $100-million, 29-acre Washington Market redevelopment.

A fine example of the part air conditioning can play in urban construction is Hartford Connecticut's new Constitution Plaza, a 35-million dollar project which, when completed in 1963, will contain three major office buildings, a 250 room hotel, a new broadcasting facility, and a shopping center.

The Hartford Gas Company will supply heating and cooling for the project. The Gas Company's new plant for central heating and cooling will be completed in 1962 for a cost of 2 million dollars.

Initially, the cooling equipment will consist of one Carrier centrifugal refrigerating machine with a cooling capacity of 3,000 tons, two smaller centrifugals with 1,500 tons each, and a 500 ton absorption unit for a total of 6,500 tons.

Mr. W. T. Jebb, President, Hartford Gas Company has cited the advantages of central plant heating and cooling as being: a space saver, eliminating the need of boiler rooms, chimneys or chilled water plants; which in turn reduces cost and eliminates the capital expense of equipment.

The reasons the Hartford Gas Company decided to go into central heating and cooling are summed-up by Mr. Jebb, who says,

" . . . like all companies these days, we are constantly looking for sound ways to expand our business and insure continued growth in the years immediately ahead. In fact, we believe that by 1965, our new plant will account for between 1 million and 1½ million dollars gross each year."

"In an alert, forward-looking community like Hartford, this can only insure our prosperity and growth."

←
Left: Aerial view of Hartford, Conn., showing proposed route of Hartford Gas Co. pipeline to supply central heating and cooling. The dotted lines indicate where pipeline may be extended in future.

ASHRAE Closes Lab, Continues Research

Board of directors of the American Society of Heating, Refrigerating & Air-Conditioning Engineers denied by a heavy majority a petition requesting a referendum vote by members on the board's recent decision to close the society's laboratory in Cleveland.

Petitions had been circulated during the semiannual meeting of ASHRAE, Chicago, Feb. 13-16 and signed by about 150 persons were presented for the board's consideration at its regular meeting during the ASHRAE Show.

At a press conference it was revealed the society plans to expand its activity in the area of environmental studies, and at present is sponsoring 12 varied research projects at nine colleges.

Outlining research plans for the immediate future, E. P. Palmatier, general chairman of the society's research and technical committees, said that present thinking calls for a $200,000 a year cooperative research program.

Of this sum, he explained, $30,000 will come from membership funds, $70,000 from exposition fees, and $100,000 from industry for specific "applied research."

OLD: Once upon a time the amount of smoke was an index of a plant's size and activity.

NEW: But here is America's newest steel mill going full blast. And where's the smoke? Gone with the help of Koppers Electrostatic Precipitators.

Koppers—a leading manufacturer of gas cleaning equipment for industry.

**Facts available on request*

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ELECTROSTATIC PRECIPITATORS

Engineered Products Sold with Service • Baltimore 3, Maryland

24,000 Sq. Ft. Of White Room Area Being Built

Aerojet-General Corp. is building a $1,250,000 plant in Azusa, Calif. to be completed in mid-April.

24,000 sq. ft. of the total 30,000 sq. ft. facility will be a super-clean area for the manufacturing, assembling, and testing of infrared subsystems for the Air Force Midas satellite under sub-contract from Lockheed Aircraft Corp.

Manufacturing Adds $1 Billion to 30 Industrial Markets

Growth of industrial buying power is shown in the 1958 Census, 30 industrial markets show at least $1 billion in value added by manufacture, compared to 21 in 1954 and only 15 in 1947.

New arrivals in the billion-dollar category are Dallas, Seattle, Louisville, Ky., Rochester, N.Y., and Greensboro, North Carolina.

Plan To Introduce New Air Pollution Bill In West Virginia Legislature

Dr. W. O. Black, president of the West Virginia Association for Purification of Air and Water plans to introduce a new air pollution control bill to the State Legislature.

The bill would be to "maintain such a reasonable degree of purity of the air resources of the state as shall be technically feasible, economically reasonable, and necessary for the protection of the normal health, the general welfare, and the property of the people of the state."

Male Death Rate Up In Britain . . . Attributed To Air Pollution

According to Britain's chief medical officer of the Ministry of Health, the 1959 mortality rate for men over 65 in England and Wales was the highest of eight countries, including the United States and Canada.

During 1959, deaths from lung cancer in England and Wales, with their damp climates and areas of dense industrial air pollution, showed an increase over 1958.

Southern California Oil Companies Spend $50,376,777 on Air Pollution

R. A. Quisenberry, chairman of the Southern California Clean Air Committee, has quoted figures compiled by the Western Oil and Gas Association showing the Southern California oil companies alone have spent, since 1948, $47,037,183 on air pollution control and $3,339,594 on research of local air pollution problems.

A survey by the APCD Engineering Div. shows the refineries in L.A. County now emit 90 ton of hydrocarbons a day, a reduction over last year of about 13 tons. The major portion of the reduction was the result of installation of waste heat boilers at refineries.

More Schools To Have Central Air Conditioning

Momentum is being gained toward central plant air conditioning for schools.

Trinity University, San Antonio, Texas, officials decided upon it, because it offers economy of operation and lower first costs than individual room or building units. It also provides more flexibility in meeting changing loads.

Kalamazoo College, Kalamazoo, Mich. has recently adopted the new 12 month school plan, which will enable students to obtain a bachelor's degree in three years. Air Conditioning will attract those who object to schoolwork in summer heat and save the College building new classroom buildings or dormitories.

Industrial Hygiene News

New Processes Health Hazards

Speaking at the Sixth Conference on Industrial Hygiene and Air Pollution at the University of Texas, Harold Magnuson, M.D., Chief of the Division of Occupational Health, U. S. Public Health Service, pointed out some of the hazards associated with new materials, machines and practices that are now in widespread use in the construction industry.

● One of the new insulating materials used for heating and air-conditioning systems is polyurethane plastic which can be extremely dangerous unless the resin is cured completely; otherwise, while cutting or sawing, workers may be exposed to vapors, usually toluene diisocyanate, a powerful eye, skin, and lung irritant.

● Some of the newer adhesives used to fasten glass fibre insulating materials to ductwork contain epoxy resins which are extremely irritating to the skin. Solvents contained in these adhesives can cause internal damage from inhaling their vapors, and dermatitis, from skin contact.

● Materials used in recent years as corrosion-resistant coatings on steel pipes and on some ductwork include polystyrene, phenol formaldehyde, plastics containing chlorine, fluorocarbon polymers or resins, and coatings containing appreciable amounts of nitrogen. Hazardous thermal decomposition products may be produced when heat is applied to these coatings, such as during welding, cutting or burning.

● A new painting technique—airless spray painting—which was introduced just a few years ago is becoming increasingly popular in regular maintenance programs because of its time-saving features. In this process, paint is heated and forced out of a nozzle under high pressure, exposing workers to high concentrations of finely divided paint pigments and solvents.

● The widespread use of copper for waterlines, gaslines and some

(Please turn to inside back cover)

which stack would YOU use for corrosive fumes?
8888-CC
This stainless steel stack failed after only 6 months in corrosion service!
Over 2 years old . . . yet this Duracor stack shows absolutely no signs of attack inside or outside!

DURACOR VENTILATING SYSTEMS PROVIDE LASTING CORROSION RESISTANCE AT LOW COST!

Performance-proven Duracor Ventilating Systems and components provide outstanding resistance to attack from all types of corrosive fumes. These high-strength systems are corrosion-proof throughout . . . are practically immune to weathering . . . require only minimum support! Best of all, Duracor construction can save you up to 30% on your initial investment . . . and it's maintenance-free! Ceilcote engineers will design a complete Duracor system to meet your special requirements . . . or modify your present system to permit gradual conversion to Duracor. Fabricated to meet customer specifications . . . or assembled from stocked component parts . . . Duracor Ventilating Systems can be easily installed by regular plant maintenance crews or by experienced Ceilcote installation personnel. Write today for the new Ceilcote catalog.

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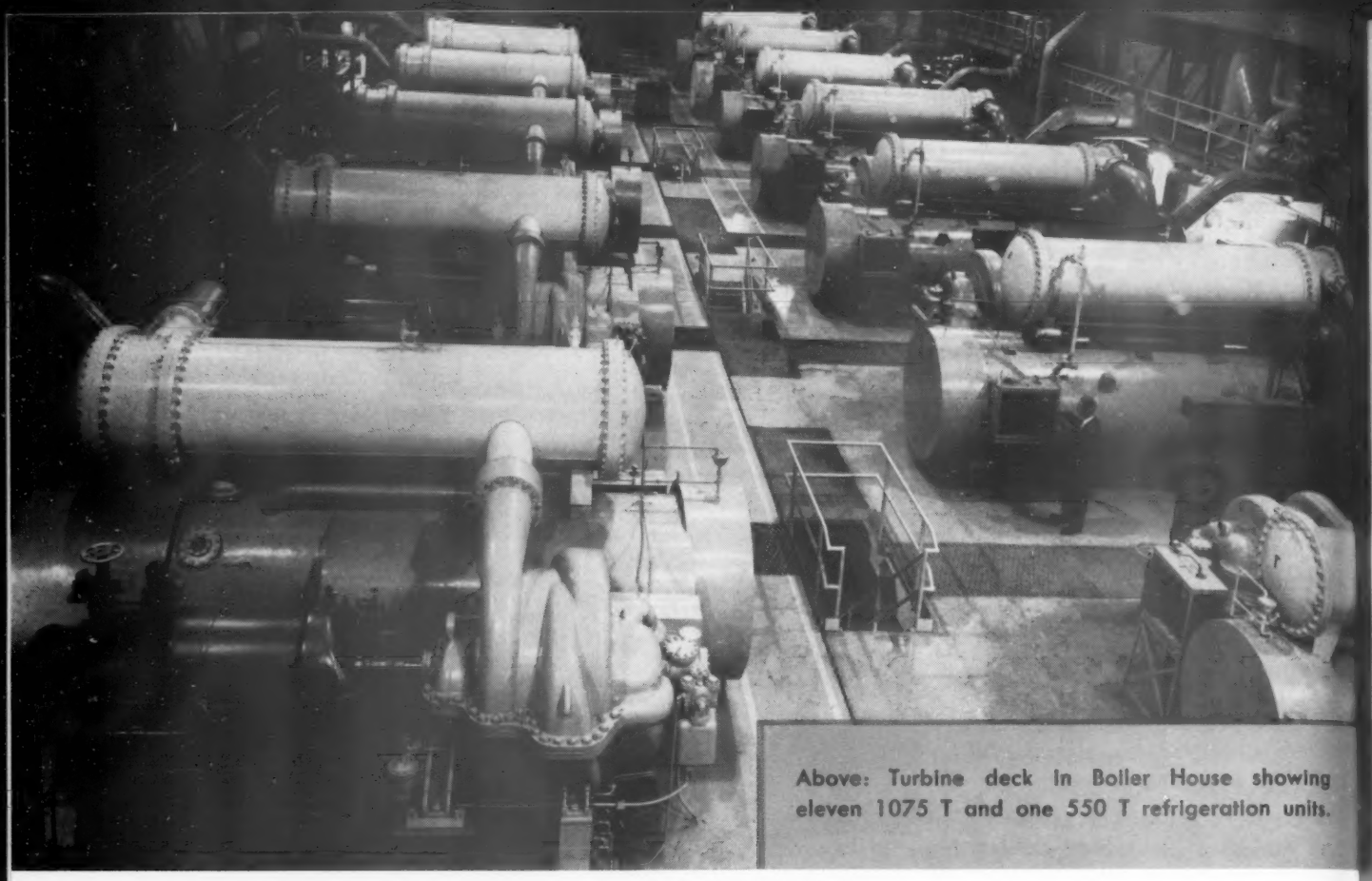


Above: Turbine deck in Boiler House showing eleven 1075 T and one 550 T refrigeration units.

18 Years' Experience At Convair Proves . . .

Plant Wide Air Conditioning Costs Only $.0471 Per Man Hour!

Factual data on operating costs . . . detailed data on maintenance of original equipment . . . system changes, in one of world's first windowless air conditioned factories.

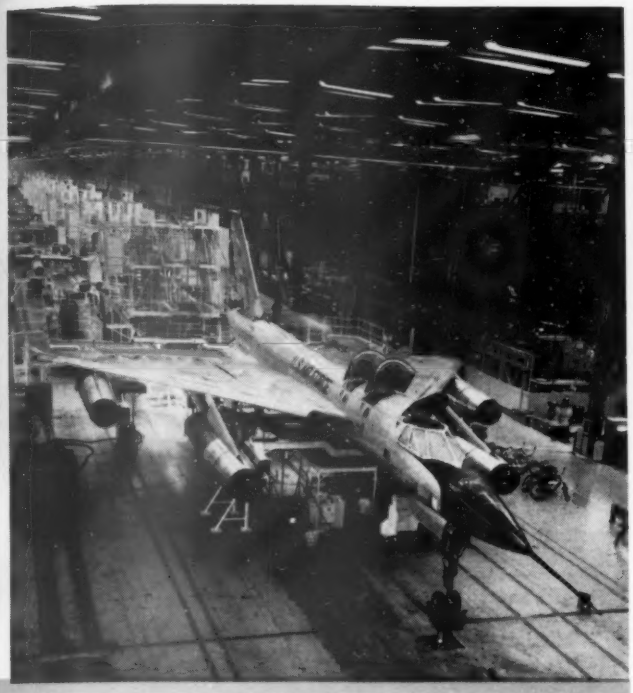
AIR FORCE PLANT NO. 4, in Fort Worth, Texas, operated by the Convair Division of General Dynamics Corporation, was the third and largest of the World War II windowless, air conditioned "blackout" aircraft manufacturing facilities. It is the only one which has been operated continuously by the same organization and personnel from initial start-up. We thus have an excellent opportunity to examine and analyze the problems of life, cost, maintenance, operation and obsolescence.

Have these factors been favorable or unfavorable? Does this installation satisfactorily fulfill its design function under changed conditions existing today? How will this installation compare with present day practice?

This plant started operation in February 1942, building B-24 bombers for the Army Air Corps. By War's end it had turned out 3000 B-24's. Late in World War II production was started on a larger, faster bomber, the B-32. Only a few were completed when, following V-J day, contracts were cancelled and all work in process stopped. The next production program was manufacture of the B-36 intercontinental bomber, which furnished the backbone of the Air Forces' retaliatory might until replaced by faster jet-age vehicles.

At present, Convair builds the Mach 2 B-58 "Hustler," the only supersonic strategic bomber in the Air Force fleet.

With the evolution of aircraft has come a great



Above: A B-58 Jet assembly line in the 200 ft. X 400 ft. main assembly bay.

by F. C. Clayton, *Chief Plant Engineer**
Convair Division
General Dynamics Corp.
Fort Worth, Texas

**F. C. Clayton started with Consolidated Aircraft, forerunner of Convair, in 1940, as an electrical engineer. He moved to Fort Worth for Convair in 1941, as plant engineer, where he has headed the Plant Engineering Dept. since its inception. He spent 2½ years with the Golden Gate International Exposition as design engineer of electric substation, distribution systems, special lighting and maintenance of large group of buildings and exhibits. He spent eight years with General Electric Co. as test, design and commercial engineer at various locations. Mr. Clayton holds a B.S. in electrical engineering from California Institute of Technology, is a registered professional engineer in Texas, and belongs to Texas and national Societies of Professional Engineers.*

change in manufacturing techniques, often creating air conditioning problems. Early aircraft were mostly of sheet metal construction, with structural members formed from strip or sheet. Today's high performance aircraft are largely machined from plate or forgings. Where sheet metal is used, machined metal tolerances must be held. *A constant temperature manufacturing environment is a great aid in meeting tolerance and quality requirements.*

The central air conditioning system at Air Force Plant No. 4 is used to control conditions and afford personnel comfort in factory and offices throughout the main buildings. This consists of 3,750,000 square feet of floor space of the plant total of 4,607,000 square feet. The balance consists of un-airconditioned warehouses and outlying buildings with their own air conditioning systems.

The central system consists of twelve steam turbine driven centrifugal compressors totaling 12,375 tons capacity. Eleven of the units are rated 1,075 tons and one, 550 tons. The turbines run on steam at 225 psi, supplied from a bank of four natural gas fired (with oil standby) boilers which also supply heating and process steam. The compressors, utilizing F-11 refrigerant, cool water which is circulated through two constant-head loops in the main factory buildings and several smaller loops to offices, cafeteria, hangars and laboratories.

Cooling water for both refrigerant and steam condensers is obtained from nearby Lake Worth, part of Fort Worth's water supply. Water is circulated by a bank of pumps at rates up to 34,000 gpm through the condensers and back to the lake, which acts as a heat sink. Only pumping cost and a theoretical evaporation loss are paid for this use of water.

Air Distribution By "Fan-Decks"

Air distribution in manufacturing and hangar buildings is by means of "fan decks" located in the roof trusses and in offices by closeted fan rooms. Several shop areas have been converted to offices by constructing complete office type buildings, less weatherproofing, within the factory. These are air conditioned by separate air handling units tied in to the chilled water loop.

Each fan deck, fan room and air handling unit consists of fresh air, face and bypass dampers, air filters, spray system, coils, eliminators and fans. The control system is pneumatic. All dampers, circulating water valves, etc. are interconnected and operated by air damper and valve motors, controlled by thermostats located in work areas.

In the manufacturing buildings and hangars, all fan decks, piping, ductwork and air outlets are kept above the 40 foot high lower chord of the roof trusses so as to avoid interference with the monorail system which covers all high bay areas. Other areas such as under mezzanines, offices, laboratories, etc. utilize standard duct systems hung under the upper floor or between ceiling and upper floor or roof where acoustical ceilings are installed.

Heating is accomplished by two methods. In the 320 foot x 4000 foot main assembly building, when on the heating cycle, the chilled water loop becomes a hot water loop by valving through steam water heaters. In addition, steam booster coils are installed in the air ducts near outside walls and doors. In other

(Please turn to following page)

Above: Aerial view of General Dynamics, Convair Division, Fort Worth Plant.

TYPICAL AIR CONDITIONED AREAS AT CONVAIR

1. **Heat treating.**
2. **Foundry.**
3. **Press area, where heated dies and adhesive curing release large quantities of heat.**
4. **Offices.**
5. **General occupied plant areas.**

(Continued from preceding page)

buildings, steam is used exclusively by means of coils mounted in the ducts. In some office areas the steam coils are arranged so they can be used as reheat when on cooling cycle, for humidity control.

Due to the construction and occupancy of the plant, there is a net cooling load at outside temperatures above 40°F. Some areas require cooling at all times, such as heat treat and foundry departments. This is also true of the press areas where heated dies and adhesive curing release large quantities of heat.

The main buildings, constructed without windows, have all walls and roofs insulated with a minimum of 4 inches of fiberglas. This gives a design heat transfer of .06 btu/hr./ft.^{2}/°F. This, together with the internal heat load of over 2,500 machine tools, 5,000 electric motors, 132,000 fluorescent lamps and (currently) somewhat over 17,500 people, accounts for the normal cooling load. Maximum steam required for cooling is approximately 173,000 lb/hr and for heating, approximately 80,000 lb/hr. About 80,000 lb/hr additional steam is used for processes, most of which appears as a load on the cooling system.

The system is designed to keep the buildings at a slight positive pressure to minimize infiltration, especially at doors. For pressure control, relief dampers are provided. Experience dictates a minimum of 16 percent fresh air in most areas. Exhausts from process equipment, paint spray booths, furnaces, etc. have increased in volume to the extent that the relief dampers seldom open and in many areas the fresh air is set at 25 percent or above.

Temperature Differential

The designers intended the air conditioning system to be operated on a temperature differential basis with the outside, with a maximum differential of 20°F for cooling. Thus inside and outside temperatures would be the same at 75°, gradually differing so that at 105° outside, the inside temperature would be 85°. Experience here favors a constant temperature from the viewpoint of employee satisfaction, machining, processes and maintenance. Therefore, a constant 75°F. is maintained throughout most areas year round. This covers a range of outside conditions varying from a rare 5° to 105°.

At outside temperatures below 50°F cooling can be accomplished in most areas by fresh air alone, at considerable savings in operating cost. With refrigeration, fresh air, warm water and steam, all available simultaneously during various weather conditions, great flexibility is possible in operation of the system. Controls for efficient utilization of these facilities are provided in a central location in the boiler house.

Operation and maintenance of the air conditioning system, including numerous smaller systems of from 5 to 200 tons, is performed by a crew of 48 men, including a foreman and an assistant foreman. Because they also operate the gas and water utility systems, compressed air systems and fire pumps, only

MAJOR COMFORT CONTROL SYSTEM MAINTENANCE PROBLEMS AT CONVAIR

1. **Cleanliness in air distribution system. In many areas, office and factory zones have common fans. Soot from factory area passes through filter to offices. Associated problems are filter selection, replacement and/or maintenance.**
2. **Control maintenance. Keeping moisture out of system . . . pressure drop at minimum . . . recalibrating thermostats and heat pilot valves . . . cleaning, lubrication of linkage, pins and motors.**
3. **Freon pump motor bearings.**
4. **Leaky heat exchangers, mostly caused by vibration.**
5. **Corrosion and pitting of centrifugal refrigeration compressor rotors, caused by acid in water-contaminated freon. Pitting caused serious rotor unbalancing.**
6. **Leaking 36-in., ¾-mile long condenser water main.**
7. **Replacement of purgers after 9 years with more modern type.**
8. **Repartitioning of office areas, and associated air distribution problems.**

26 of this crew can be charged properly to the central air conditioning system.

Four posts are filled, consisting of boiler firemen, turbine deck operators, "under deck" operators (who also operate air compressors) and pump house operators. All are three shift, 7 day per week except the "under deck" post, which is filled on a two shift, 6 day basis. The operating crew rotates in both shift and work week on a 4 week schedule.

The maintenance crew normally works a single shift, 40 hour week. Work requiring a shutdown is performed on Saturday or Sunday, on an overtime basis. This crew does all preventive maintenance, repair and overhaul work except electrical; services air filters and maintains the control system. This latter function ties in intimately with employee satisfaction, as the men who test and adjust thermostats and dampers represent attention being given to their comfort. Rebalancing of air distribution for summer and winter operation has been found necessary in some office areas.

Maintaining Cleanliness

The number one continuous maintenance problem is maintaining cleanliness in the air distribution system. In many areas the fans are common to both factory and offices. Soot deposits from smoke and other airborne contamination from factory areas pass through the filters and settle out in offices. This is particularly noticeable as discoloration on ceilings around aspirating diffusers. To combat this, many disposable and washable type filters have been installed in ducts and air handling units. Changing and cleaning these is a steady task. A number of electrostatic filters have been installed in individual air ducts supplying dust controlled rooms to meet special requirements.

Maintenance of the primary moving curtain oil type filters has been a problem, mainly with the filter drive units. These drive the curtains intermittently, allowing the bottom loop to pass through the oil trough, washing off dirt and recoating the curtain blades with viscous filter oil. The original drive units were sprocket type which have given much trouble and are now obsolete. In 1944 about ⅓ of them were replaced with the newer ratchet drive. The remainder are to be replaced soon under the current "rehabilitation" program.

Other filter maintenance items are repairing and replacing blades in the curtains and cleaning of curtains and oil reservoirs. Cleaning is accomplished

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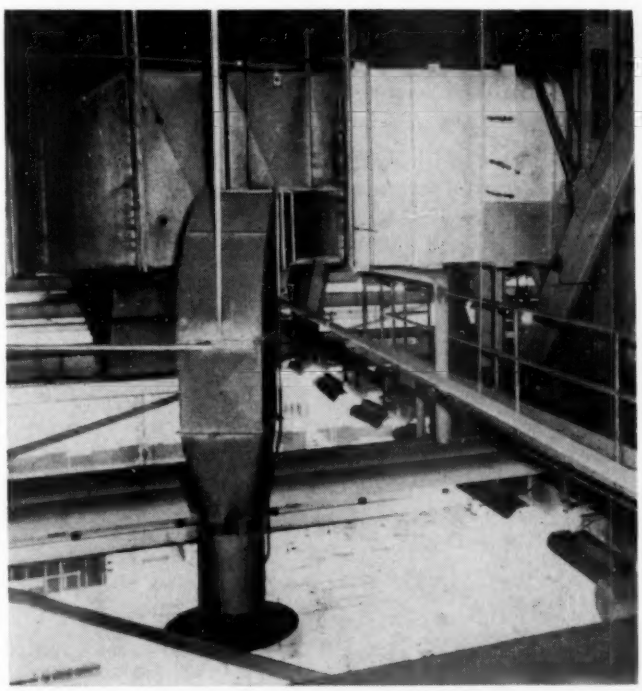


Above: Typical Assembly Building fan deck in truss over 200 ft. span main assembly bay, showing chilled water piping and typical duct arrangement. No, photo is not upside down, it just looks that way.

(Continued from preceding page)

while the corresponding fan is shut down by draining the oil and filling the reservoir with detergent solution. Steam is used to bring the detergent to a boil and the curtain is rotated through this bath. Solution is then drained and oil replaced. All filters are cleaned in this manner on a regular schedule.

Control maintenance problems appeared soon after completion of the original installation in that the pneumatic control lines were undersized and inadequately trapped. Traps were installed to eliminate moisture and main air lines were increased in size to eliminate pressure drop. Cleaning and lubrication of damper pins, linkages and motors to prevent sluggish and erratic operation has been a problem. Many are installed in relatively inaccessible places and special means have to be taken to reach them. Calibration of thermostats and reheat valve pilots and replacement of damper motors, motor diaphragms, steam and hot water valves are other constantly recurring problems.

Following is a description and chronological list of major maintenance and modernization of the air conditioning system since original installation. Work done in 1953 was funded under a "deferred normal maintenance" concept. During the years 1947-52 the plant was working at such a high level of production that normal maintenance requiring a shutdown could not be performed and had to be deferred. This was recognized by the Air Force and a special fund was set up to pay for this type of work when production slacked off. Since 1957, annual appropriations have been made for "rehabilitation" and modernization of the plant, including the air conditioning system.

Chronological Maintenance And Modernization

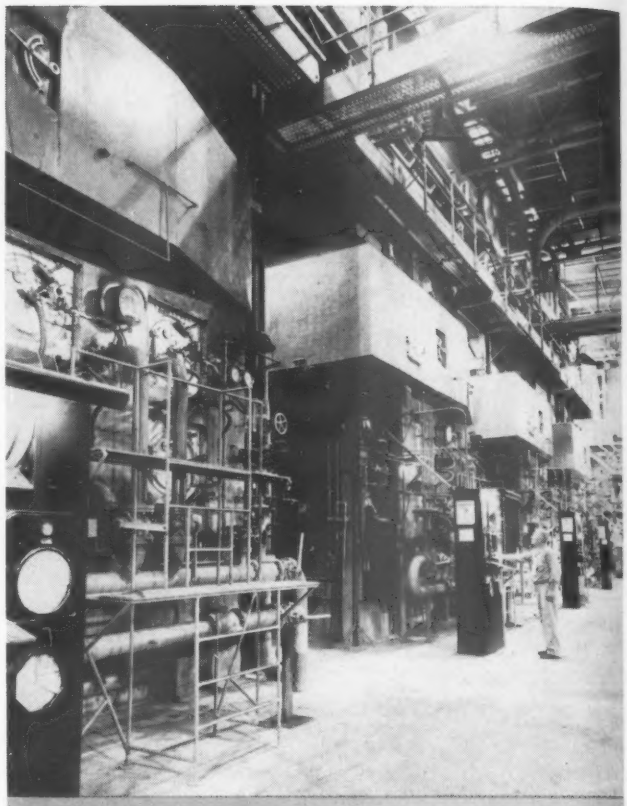
1942 – Six 1075-ton and one 550-ton centrifugal refrigeration units were installed and placed in operation.

1943 – Five 1075-ton units were installed making a total of 12,375 tons of refrigeration equipment in service.

Refrigeration units are composed of a turbine driven 3-stage centrifugal compressor with shell and tube type evaporators and condensers, the evaporators being equipped with vertical freon-11 pumps direct connected to totally enclosed motors, with the pumps submerged in freon, operating without lubrication.

Serious troubles developed in freon pump motors, due to bearing design, which resulted in overheating and burning of motor windings. To make pumps and motors operational it was necessary to redesign the bearing arrangement, replacing Graphex bearings with sealed ball bearings and applying means for lubrication. Refrigeration was also supplied to the motors by piping saturated gas through the motors to provide necessary cooling.

1944 – The heat exchangers which supply hot water through Assembly building coils developed leaks in tubes. Leaks were caused by tubes vibrating in tube spacer sheets, wearing holes in tubes.



Above: A view of four 100,000 lb/hr boilers.

1945 – More leaks developed making it necessary to retube the heaters. The tube spacer sheets were replaced with ¾-in. thick Neoprene rubber and to this date have been trouble free.

When water is mixed with freon an acid condition is created which seriously affects component parts of the refrigeration system. In 1945, serious vibration developed in No. 5 centrifugal compressor. The compressor rotor was removed and returned to factory for rebalancing. This unbalanced condition was due to corrosion and pitting of rotors, which was caused by the acid condition. Freon water contamination was traced to leaking condenser tubes, which were then plugged.

1947 – Leaks developed in freon condenser tubes, making it necessary to retube the condenser. After tubes were removed from condenser, inspection revealed that acid had affected the tube spacer sheets to a point where tubes became loose and vibrated, wearing holes in tubes. The tube spacer sheets were replaced with stainless steel.

1948 – It was necessary to retube and replace spacer sheets in four freon-11 condensers. When ordering tubes, it was decided to have tubes made

with finned surfaces between spacer sheets, leaving 2-in. blank spaces at tube sheets to retard vibration.

1949 – The 36-inch steel condenser water main from the pump house, approximately ¾-mile long, developed leaks and was replaced with a pressure concrete pipe line at a cost of approximately $32,000.00. The old line, inaccessible for removal, has been cement lined and is used as a storm drain.

1950 – Three freon-11 condensers were retubed and spacer sheets replaced with stainless steel.

1951 – 12 purge units were replaced with more modern type.

1953 – Funds were made available for the overhaul of all air conditioning fan decks. This work was accomplished as follows. Air flow checks across coils and pressure drop through coils were made to determine the need for cleaning tubes and finned surfaces of coils. Coils with steel tubes and fins were replaced. All coils that appeared to be plugged were removed from fan decks, completely dismantled, cleaned, reassembled and reinstalled. Filters were cleaned by revolving curtain through hot detergent in oil reservoir. Fan rooms were thoroughly cleaned, canvas connecting rings and door gaskets were replaced, dampers were reworked and adjusted. All pneumatic motors were changed . . . pneumatic controls were lubricated and calibrated.

Air heater tubes were replaced in Nos. 1, 2, 3 and 4 boilers along with the repairing of furnace refractories. Burner and squaring tiles were replaced. All furnace work was performed on outside contract. All maintenance of boilers prior to 1953 and to present date has been normal and in compliance with boiler inspector's request, with exception of replacement of a section of ten circulating tubes in No. 1 boiler.

1954 – Retubed one refrigeration condenser and replaced tube spacer sheets with stainless steel.

1957 – Funds were approved for rehabilitating five 1075-ton refrigeration units by replacing obsolete chillers and condensers with flooded type chillers and modern condensers. Compressor rotors were checked for balance. Rotors out of balance were sent to factory for rebalancing. Shut down seals were discarded and replaced with mechanical carbon seals.

1958 – Three 1075-ton refrigeration units were rehabilitated in the same manner as described above.

1959 – Three additional 1075-ton refrigeration units were rehabilitated in the same manner.

1960 – One 550-ton unit rehabilitated, making twelve units in a like new condition. Steam turbine rotors were replaced and turbines overhauled under the rehabilitation program. Rotors were replaced due to wire drawing of shaft at seals and rotor wheels.

When current rehabilitation work in progress and planned is completed, the system, from an efficiency standpoint, will be "like new." Performance of the modernized refrigeration units will approach or equal that of currently manufactured equipment.

The system still has its shortcomings, particularly in office areas. Partitioning of open areas into offices creates control problems which can only be solved with somewhat less than satisfactory compromises, although system capacity is ample. In some cases, where several offices are handled by a single duct, and where volume control is not satisfactory, individual electric reheat coils have been inserted in the branch duct and controlled by a room thermostat separate from the basic control system.

Except for this kind of problem, it is felt that the air conditioning system is capable of satisfactorily fulfilling its purpose in the foreseeable future.

Any assessment of cost of operating the central air conditioning system for comparison purposes should recognize several factors. First, original cost figures are those incurred in 1942, and do not represent replacement cost. Second, utility costs have risen at various rates during the past 18 years. For example, electrical energy has risen 10 percent to a present average of $.0075/kwh. Natural gas has risen 85 percent to its present $.195/mcf average. Water cost has increased approximately 40 percent.

Since all supplies have also increased proportionately and labor has risen approximately 300 percent, only current operating and maintenance costs are used. Annual costs on this basis are approximately as follows:

Labor and supervision	$144,000	
Materials and supplies	63,000	
Electrical power	216,000	
Natural gas	130,000	
Water	18,000	
Total overhead cost/year	$715,000	
Cost/employee (18,000)/year		$39.70
Cost/direct labor hour (1960)		$ .0318

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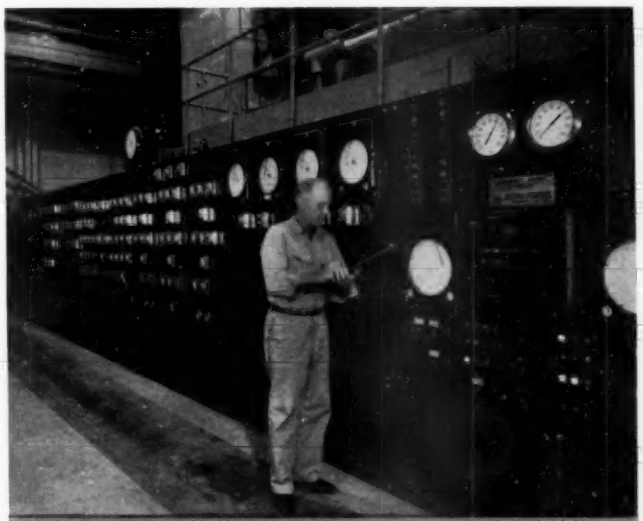

Above: The central air conditioning control panel in the Boiler House.

STYRENE? PVC HIGH IMPACT? POLYETHYLENE? NEOPRENE? ABS?
PVC NORMAL? PE LINEAR? PE BRANCH? BUTADIENE?

How To Handle **Corrosive** *Gases*

For a quick review of which anti-corrosive material to use for what corrosive fume, gas or mist, this informative article will be a valuable addition to your technical data file.

by Frank J. Versagi*

MOTIVATED EITHER BY civic mindedness or public pressure, an increasing number of manufacturers are taking measures to keep destructive and hazardous chemicals out of their neighborhood atmosphere; moved either by genuine concern for their employees or by official censure, factories are taking steps to remove irritating and harmful fumes and mists from work areas.

Even in this enlightened era, however, tens of thousands of workers and millions of residents are exposed daily to such air contaminants as

- – hydrochloric, nitric, sulfuric acid fumes from pickling operations;
- – plating room exhausts;
- – sulfur dioxide and fly ash from flue exhausts;
- – chlorine fumes from bleaching and decontaminating operations;
- – smelter dusts;
- – radioactive vapors.

Some are not so concerned with health hazards as with the destructive effects of these corrosive substances – destruction which calls for millions of dollars annually for maintenance, repair, and replacement.

Any action to control and eliminate aggressive fumes and mists requires a decision on materials of construction and methods of fabrication of the fume handling system. Consideration must be given to the fact that maintenance costs over long periods of operation are frequently more important than the initial cost of the fabricated items. On the other hand, if the fume handling setup is for a temporary process, it is usually wiser to use less permanent and less costly materials and fabrication methods.

The increasing introduction of new materials into manufacturing operations is extending the temperature and concentration limits which must be withstood by the fume handling system. The use of hot, concentrated nitric acid on titanium alloys is a case in point.

Corrosion resistant materials, from which fume handling systems are fabricated may be arbitrarily classified into three groups – metals, minerals, and plastics.

The conventional metallic materials are plain steel, galvanized steel, stainless steel, monel (nickel-copper-iron alloy), and, perhaps, aluminum and aluminized steel.

Mineral materials include stoneware, porcelain, cement-asbestos mixtures, and glass.

Plastics used in fume handling systems are polyvinylchloride, polyethylene, polyesters of several types, polypropylene, and acrylonitrile-butadiene-styrene compounds. This category may be stretched to include rubber and other elastomeric substances used as coatings or linings over various metals.

The use of wood for handling corrosive materials is obsolescent.

These several materials are used, jointly or exclusively, to fabricate hoods, ducts, stacks, tank covers, tanks, fans, air washers and scrubbers. Cost of an installation varies with dimensions and weight of materials, methods of joining and fabrication, the

**Frank J. Versagi, editor of our sister publication,* AIR CONDITIONING, HEATING & REFRIGERATION NEWS, *was formerly chief chemist of Mueller Brass Co., Port Huron, Mich. Among his duties were direction of the company's corrosion research program and the development of its plastic product line.*

availability of standard fittings, and familiarity of workmen with the specific materials involved.

Simplest corrosion control is obtained by painting normal structural metals with any of the scores of acid-and alkali-resistant paints on the market. This method is usually cheapest if the installation is temporary or if corrosivity of the aggressive medium is relatively mild.

The major weakness in painted protection is that any pinhole, any break in the paint coating serves as a nucleus for extensive corrosion. One table salt producer has a paint crew which circulates through the plant continually painting and repainting all exposed piping and sheet metal. The company operates on the theory that this maintenance expense is less costly than replacement of the piping and sheet materials with more corrosion-resistant types.

In direct contrast, a large manufacturer in the western part of the country has replaced all of its steel lines with polyvinylchloride pipe, even though its plant atmosphere is not corrosive – just to save the money of painting twice a year, which was its policy.

Greater corrosion protection than available with simple painting is obtained by coating or lining the metal with some elastomeric material. (Conventionally, *coating* refers to application of the elastomeric compound by spraying or dipping; *lining* denotes the bonding of sheet material, elastomeric or rigid, to the base metal.)

Plating room designers are especially fond of elastomeric coatings because of their success with these materials as rack coatings, which take much abuse and are actually immersed in hot chemical media in addition to being exposed to vapors and mists. In fact, plating room supply firms offer special coatings for application to ducts, hoods, fans, and tank covers. Both rubber-base and plastisol compounds are used for such applications.

Some plating firms have gone so far as to coat fan blades. However, since the fan was not designed for this load, and since the coating may be unevenly applied, such practice usually leads to fan bearing failure or motor burnout.

Elastomeric linings are more often used in tanks than in fume handling systems. In any case, especially when the more rigid materials are used, it is important to consider the difference in the coefficients of expansion between the plastic and base metal. Since plastic C's-of-E are usually 3 to 5 times those of metals, the bond must be able to withstand a great stress during differential thermal expansion and contraction of the two materials. To overcome this problem, some rigid linings are applied as inserts – plastic tanks inside a steel shell.

While less susceptible to the defect than painted protection, coatings, too, may allow corrosion to begin at isolated nuclei where a blow has punctured it or where the coating has thinned around a sharp corner.

Of the corrosion resistant metals, themselves, only stainless steel has found wide acceptance for fume handling. Monel is used primarily for pipes and fittings; galvanized materials are used chiefly for exposure to mild, usually atmospheric, media. In the minds of many, stainless is unsurpassed for handling nitric acid fumes. One company reports good results with stainless steel hoods and ducts over a hot, 220°F, sulfuric acid electrolyte bath.

Stainless steel has the advantage, too, of familiarity. Metalworkers are accustomed to handling the sheet and with welding it. It is these welds which create

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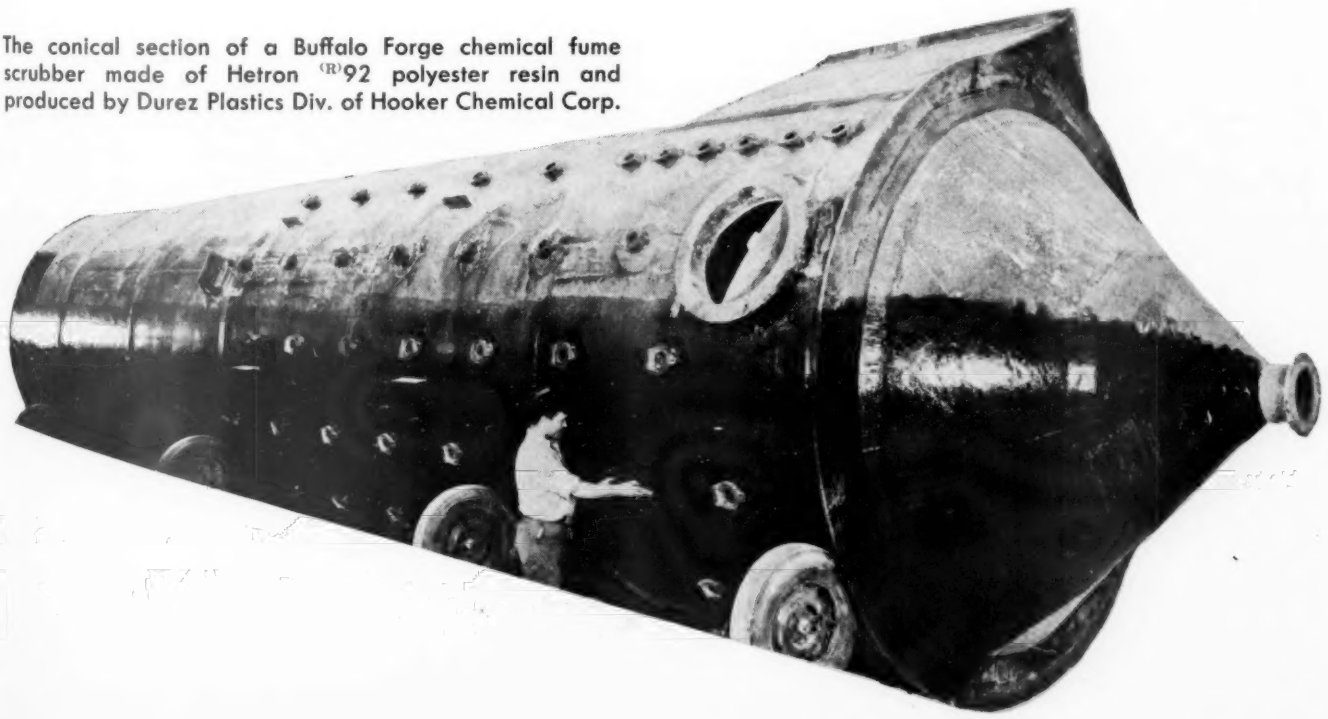

The conical section of a Buffalo Forge chemical fume scrubber made of Hetron (R)92 polyester resin and produced by Durez Plastics Div. of Hooker Chemical Corp.

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the chief disadvantage of using stainless. The welds are always the first to begin corroding under aggressive exposure, and rusting then spreads to the parent metal.

Stoneware, classically applied in chemical laboratories, has found limited acceptance in industrial fume handling. Like monel, it is used chiefly for fluid flow. Stoneware is heavy; as pipe, it is supplied in relatively short lengths, calling for many joints. It is best applied where it is out of the way – where it is not liable to accidental blows from workers' tools, moving machinery, and the like. Stoneware also finds application in air washers as discussed later.

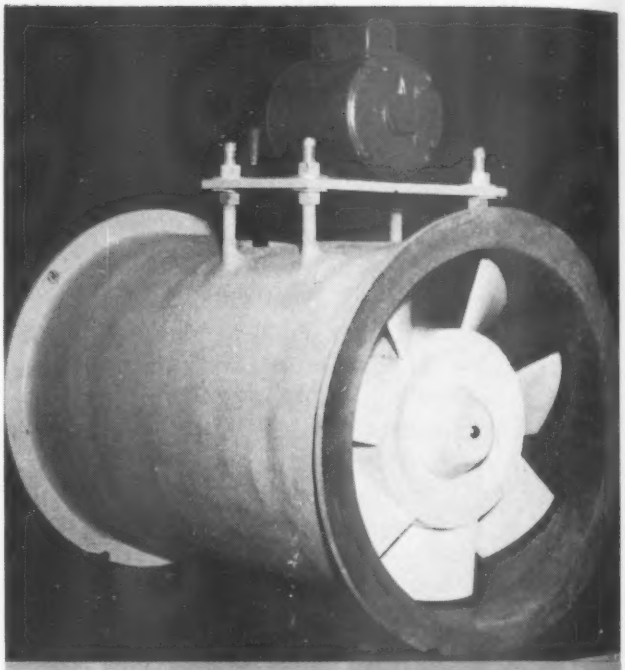
Cement-asbestos mixtures are used extensively as vent pipe to exhaust corrosive fumes from plant and laboratories. Recently, there has been some application of this same material to fume hood and ductwork, although its use for such purposes is not recommended by the manufacturer. The simple cement-asbestos mixture is relatively porous and is not impervious to acid and alkali attack. Several have been surprised at the rapid rate of deterioration of this material when it is misapplied.

There are cement-asbestos materials which have been impregnated or coated with inert substances, such as epoxies, and which are recommended for fume handling systems. Such systems are expected to last several years with minimum maintenance.

RECOMMENDED EXHAUST RATES FOR OPEN TOP PROCESS TANKS

Operation	cfm/sq ft of solution surface
Degreasing	
Trichloroethylene	225
Carbon tetrachloride	225
Plating	
Arsenic	175
Cadmium	200
Chromium	200
Cyanides	200
Anodizing	200
Aluminum Bright Dips	250
Pickling	
Cold Acid	150
Hot Acid	250
Nitric and Sulfuric Acids	250
Nitric and Hydrofluoric Acids	250
Cleaning	
Caustic or Electrolytic—not boiling	200
Caustic or Electrolytic—boiling	250
Bright Dip—strong Nitric Acid	250
Stripping	
Concentrated Nitric Acid	250
Concentrated Nitric and Sulfuric Acids	250
Salt Baths (molten salt)	120
Salt Solution (Parkerize, Bonderize, etc.)	
Not boiling	120
Boiling	250
Hot Water (if ventilation desired)	
Not boiling	120
Boiling	250

According to Fred W. Arndt
Heil Process Equipment Corp.



Above: Fiberglass fan for handling corrosive fumes. Picture courtesy of Industrial Plastic Fabricators, Inc.

Porcelain and ceramic coatings are best applied to components of fume handling systems, such as blower blades.

There is no doubt but that plastics are taking over as the most universally applicable materials for corrosive fume handling. Know-how has reached the stage where every component in a fume handling system in contact with the flow stream can be fabricated of plastic. Plastic fabricators are beginning to use corrosion engineers as field representatives. These men sell to solve a problem, and a healthy industry is developing to replace the undesirable image cast by gross misapplication of plastic materials in earlier years.

While many plastics have been applied, the competition is strongest among polyethylene, polyvinylchloride, and reinforced polyesters. Complete systems, including fans, are available in these materials. None of the plastics is the answer to all corrosion problems, a point which may be discovered after applying the wrong one. Even today, some engineers mistakenly hold, "A plastic is either good for a chemical or it is not. There is no progressive corrosion as there is with some metals."

Experience with stress cracking of polyethylene is the best refutation of this statement, since there is clear evidence that such cracking is directly influenced by certain classes of chemicals by which the plastic is initially unaffected. It is true that for most chemical service, the *physical*, rather than the *chemical* prop-

PHYSICAL PROPERTIES OF COMMON PLASTICS

PROPERTIES	PVC Poly Vinyl Chloride	POLYETHYLENE High Density	POLYETHYLENE Medium Density	ABS Acrylonitrile-Butadiene-Styrene Copolymers	POLY-PRO-PYLENE	GLASS REINFORCED POLYESTER Chopped Roving	GLASS REINFORCED POLYESTER Woven Cloth
Tensile Strength P.S.I.	3000-5000	3100-5500	1200-3500	2500- 9000	4300- 5700	10,000-25,000	30,000-50,000
Compressive Strength P.S.I.	2000-2700	2400	..	2500-11,000	8500-10,000	15,000-30,000	25,000-50,000
Impact Strength Ft.—Lb./In. of Notch (½" × ½" Bar—Izod Test)	0.3-1.0	1.5-12.0	0.5-5.5	0.7-12.0	0.6-6.0	5.0-30.0	5.0-30.0
Flexural Strength P.S.I.	4200-6200	1400	4800-7000	3600-13,500	..	10,000-40,000	40,000-80,000
Specific Gravity	1.65-1.72	0.941-0.965	0.926-0.94	0.99-1.10	0.90-0.91	1.35-2.0	1.50-2.1
Thermal Expansion 10-5 per °C.	19	11-13	..	6-13	11	2-5	1.5-3
Maximum Working Range—Temperature °F.	130-150	140-180	120-150	165-225	210-230	200-300	200-300

erties of the plastic are the determining factors. Cold flow of polyvinylchloride is an example. Temperature and structural limitations are another.

In such processing as involved in drugs, dyes, and foods, the use of plastics has the added advantage of preventing contamination of the product. Contamination prevention is extremely important in such processes, so much so that resort is frequently made to ion-exchange resins to control impurities. In a plating room, iron dissolved in mist from a chromic acid bath and falling back can ruin the chrome plate.

Because of the polysyllabicism of most plastic names, trade names have been introduced in confusing proliferation. Realizing this, a few producers are starting to use actual names or standardized abbreviations in all discussions. While no standard nomenclature has been developed for common usage, these are the most frequently suggested designations for the common plastics used in fume handling systems:

Chemical Name	Recommended Usage
polyethylene	polyethylene or PE
polyvinylchloride	PVC
acrylonitrile-butadiene-styrene compounds	ABS
polyesters	polyesters
polypropylene	polypropylene or PP

PVC has the longest commercial history. Actually, it had proved itself in France and Germany for 10 to 15 years before it was introduced into the United States. It is supplied in two types of resins: Type I is known for ultimate chemical resistance and intermediate physical properties; Type II is known as high-impact PVC. It has higher physical properties but somewhat lower corrosive resistance than Type I.

The properties of ABS materials are quite similar to those of PVC, and the two are directly competitive in many applications.

Polyethylene, like PVC, is supplied in two types, *branch* and *linear*. The linear material has generally higher physical properties than branch polyethylene, although the latter is much more frequently encountered. PE's most noticeable defect is a tendency toward stress cracking with age in certain environments and a relatively low temperature limit.

Filled polyesters are finding more and more applications in fume handling systems. Also called reinforced resins, these thermosetting materials are fabricated simultaneously with being compounded. A hood, for example, is fabricated by applying the resin compound and filler over a form and allowing the plastic to cure. The elimination of the labor cost

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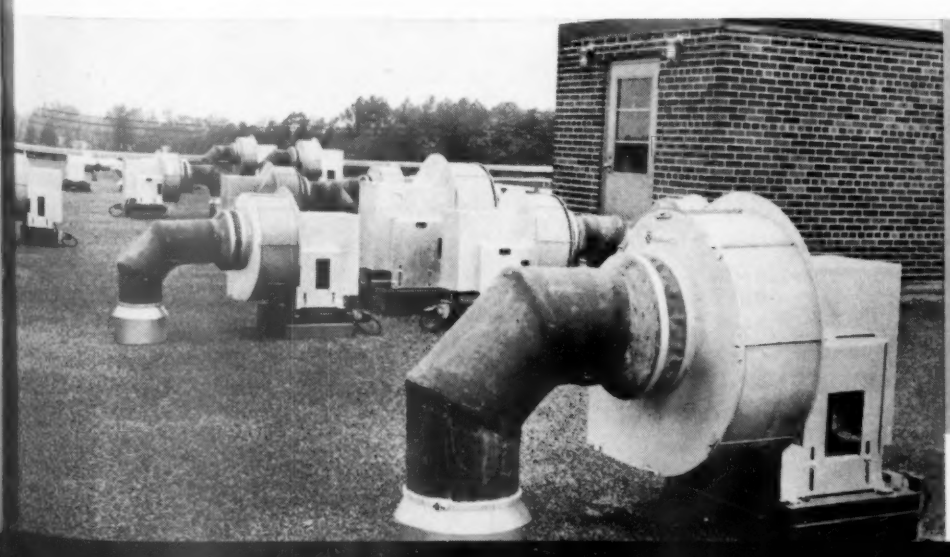

Left: Heil Centrifugal fans, built of Rigidon plastic. Each fan exhausts the fumes from a separate hood in the building. Capacities of the fans range from 1000 cfm to 3400 cfm.

(Continued from preceding page)

involved in manufacturing, say, a sheet of PVC for later fabrication by more labor, frequently gives filled polyesters a first-cost advantage.

While glass-filled polyesters are most familiar to engineers and laymen, different reinforcing agents are used depending on the end use envisioned for the fabrication. Asbestos, orlon, and dacron are among the fillers employed. "I wouldn't drive my Corvette into a tank of sulfuric acid," is the way one plastics engineer emphasizes the different properties obtained by changing fillers and polyester compounds.

Polypropylene, a chemical cousin of polyethylene, is the newest thermoplastic to enter the picture for fume handling systems. Its long-time properties are not yet fully established, although there is considerable laboratory data on the material.

Engineers unfamiliar with plastics applications, frequently fear their relatively low temperature limits. In practice, the temperature limitations are frequently insignificant. PVC, for example, with a working temperature limitation near 160°F, has found successful application over boiling acid solutions. The explanation is simply that so much air is moved over the bath and through the exhaust system that highest temperatures in the ductwork or hood seldom exceed 130°F.

Direct Cost Comparisons

It is meaningless to attempt direct cost comparisons of fume handling systems fabricated from the various metallic, mineral, and organic materials available. Cost ratios which apply to a 12-in. duct, say, are not valid for a fabricated hood or a fan housing. Labor costs vary with the know-how of personnel, with whether or not the system is fabricated by the supplier and assembled on the site, and with the material used.

What surprises many is that all-plastic systems can cost more than more traditional materials. The surprise is usually greatest in those who are not as yet convinced that plastics are valid structural materials, not merely *ersatz*.

Sheet metal fabrication techniques are traditional. In fume handling systems, welding is the usual joining method, with nuts-and-bolts used where flanged connections are desired. Stainless steel systems will last several years if the exposed surfaces are flushed periodically with water. Once corrosive attack begins, stainless systems are difficult to keep intact. A familiar sight is a stainless steel hood with numerous patches of bright metal surrounded by rusting welded joints. Experience is that operating personnel take literally the term *stainless*. The material is valuable in corrosive fume handling, but requires maintenance.

Cement-asbestos systems have temporarily encountered a dubious reputation because individual plants have unknowingly misapplied uncoated material in fume handling systems. The unprotected, relatively porous surface of the conventional structural material is readily attacked by strong acid and alkali, and deterioration begins within months of the installation. Experience with the coated or impregnated cement-asbestos mixtures has been good, but no life expectation figures are yet available.

Virtually Maintenance Free

PVC, ABS, PE, and reinforced polyesters have all been used in the fabrication of complete fume handling systems. All-plastic fans, nuts and bolts, plastic welded joints, structural members have brought testimonials of virtually maintenance-free satisfaction for years.

An all-plastic fan, for example, will require more horsepower to operate than a comparable rubber coated metal fan – perhaps a 10-hp motor instead of a 7½ – but fan life is longer. Fans are fabricated with the same procedures as hoods and ducts.

In PVC, and polyethylene they are welded, in polyesters they are cast over forms and segments are cemented with parent material.

PVC and polyethylene are usually heat welded; hot air or nitrogen is fed over a plastic welding rod or over two pieces of material which go into a butt weld. (The use of inert gas for hot gas welding of polyethylene has been considered necessary to prevent oxidation of the material; there is increasing evidence that such a precaution may not be necessary and that air may be safely used.)

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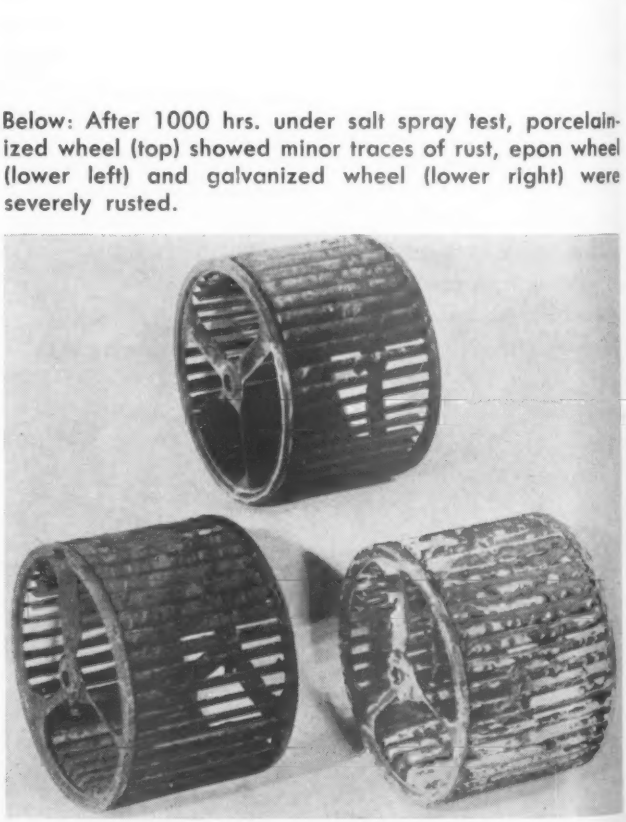
Below: After 1000 hrs. under salt spray test, porcelainized wheel (top) showed minor traces of rust, epon wheel (lower left) and galvanized wheel (lower right) were severely rusted.



What you should know about

Electrical Requirements Of Electrostatic Precipitators

Factors considered include . . . gas volume, corrosiveness, temperatures, type dust involved, location and outdoor ambients.

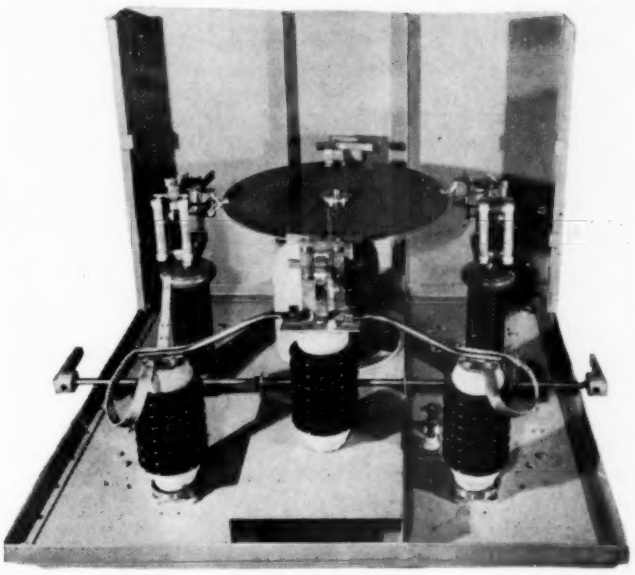


Fig. 1: Mechanical type rectifier. Maintenance of moving parts is a drawback.

by **L. L. Nagel**
Chief Electrical Engineer
Buell Engineering Co., Inc.

IN THE SELECTION of an electrostatic precipitator, one of the factors the plant engineer must be concerned with is the electrical requirement. These in turn depend upon a number of considerations, most notably gas characteristics, dust analysis, and collection efficiency desired.

The plant engineer is generally not familiar with the specialized procedures required to evaluate these factors, and sooner or later turns to a precipitator manufacturer for assistance. Some manufacturers provide this technical help from the earliest planning stages. However, should the plant engineer not wish to bring a manufacturer into the picture at this early stage, he can submit, along with a sample of the dust to be collected, the following information:

1. Volume of gas to be handled under normal conditions.
2. Volume of gas to be handled under peak conditions.
3. Temperature range of the gas.
4. Gas corrosive characteristics at normal process temperature.
5. Dewpoint of the gas.
6. Geographical location and outdoor temperature range.
7. The available electrical supply with respect to voltage frequency and number of phases.

The dust sample submitted can be collected at any convenient place between the process and the stack but should not be taken from any type of existing collectors or from the base of the stack. These samples are not representative of the true composition of the dust. The most accurate method for the collection of a representative sample is to tap the gas duct close to the process exit and collect the escaping dust, using the standard ASME sampling procedures.

At least a one quart sample of material is required. The dust should never be collected or placed in a metal, paper, or other type of container which could possibly change the original moisture and/or chemical characteristics of the sample.

Pitot Tube Readings

Pitot tube readings during maximum process conditions will provide a reasonably accurate measure of the range of gas volumes encountered. Temperature readings taken at the same time will provide the range of temperatures involved.

If the necessary equipment or personnel is not available, the plant engineer can permit a manufacturer's test engineer to collect a specimen, using the prescribed ASME method. The collected sample would represent an accurate specimen of the dust involved and since the engineer knows the elapsed time during which he collected the specimen, calculation of the total dust involved per day is easily made.

The quantity of gas involved can be determined at the particular time the test is made; however, this might not coincide with the maximum conditions prevailing under other manufacturing conditions, or during other seasons of the year, and if not, more representative data will be required.

At the same time the test engineer obtains the specimen, he can also make a test for the electrical resistivity of the dust under actual flow, temperature, and humidity conditions. Later, a chemical and particle-size analysis can be made and from this information a very thorough picture of the characteristics of the dust is obtained.

The plant engineer has at his option a service provided by several of the precipitator manufacturers. This service includes the assembly of a portable precipitator, complete with power pack, adjacent to the duct carrying the gas to be analyzed. By connecting the portable precipitator to the gas duct, a

(Please turn to following page)

(Continued from preceding page)

portion of the gases to be cleaned can be fed to the test unit, cleaned, and returned to the duct. In this manner very accurate data pertaining to precipitator size and electrical requirements is obtained. This service is available on a small fee basis which, in some instances, is absorbed into the cost of the precipitator if purchased.

The desirability of a pilot precipitator operation cannot be overemphasized. A quote based upon such a preliminary study will accurately reflect the final ultimate cost and often will achieve a saving in the purchase price of a full size unit. When a precipitator is contemplated for a new processing plant, accurate design data may often be obtained by sampling dust and gas from a similar existing plant.

Precipitator Location

Another practical consideration of importance to electrical and mechanical design, is space availability. The plant engineer can obtain this information from his plant layout. With the aid of these drawings, a placement plan can be constructed indicating available locations for the precipitator, control cabinet, transformer-rectifier and distribution switchgear. The location of the control cabinet is of considerable importance with respect to the maximum ambient temperatures that may be encountered.

Electrical control components are normally designed to operate at a maximum ambient temperature of 40C (104F). Should the selected location require control components to operate at a higher ambient, they can be so designed; however, the approximate maximum ambient operating temperature at the planned location should be given.

It should be noted that the electrodes which charge the dust particles as they are borne through the precipitator carry a DC charge of from 40 to 80KV peak value and that the DC current flow at these voltage levels are in the range of 0.1 to 1.2 amps. Thus, the basic problem of transforming incoming power, normally at 440V AC, to that required for the particular precipitator, and of rectifying this from AC to DC. Note that while the DC voltages encountered are very high, the DC currents are comparatively small.

Determination of exact power requirements must be left to the equipment supplier since experience and know-how are two of the most important factors in this area. There are no rules that can be stated which will enable the plant engineer to do this himself.

For example, the amount of power taken by a particular process is not a direct function of the quantity of gas treated. As a case in point, the power requirements of a small precipitator unit handling 50,000 CFM of gas is proportionally greater than that of a precipitator unit handling 200,000 CFM of a gas having the exact same characteristics. It is therefore necessary to introduce a proportional electric power requirement factor where the original power requirements were based upon a smaller or larger unit.

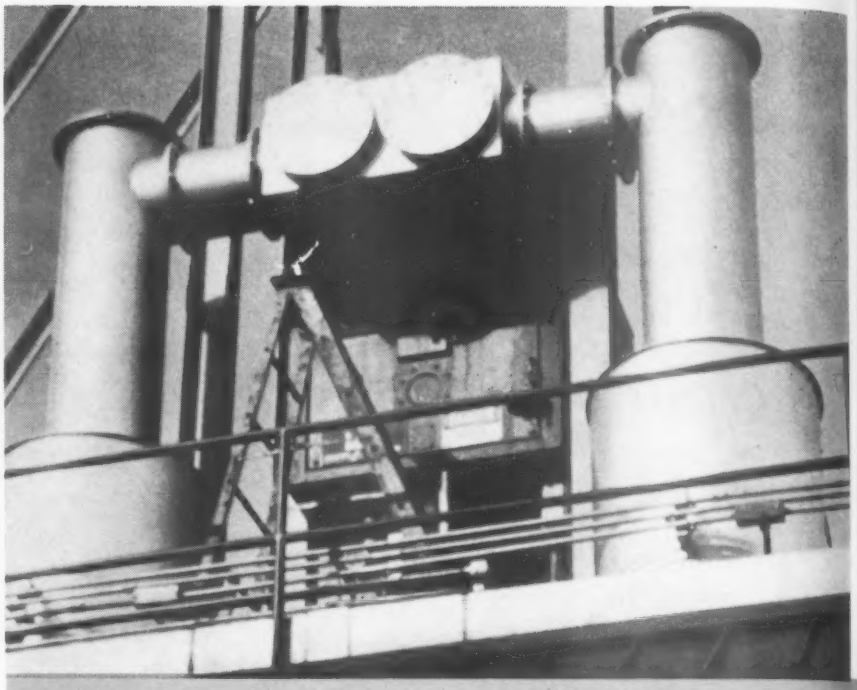


Fig. 2: Housed mechanical type rectifier atop precipitator requires more space than later date types. Cylindrical guards house iron pipes which conduct power from switchgear to precipitator frames.

Suitable Switchgear

Once the incoming power has been transformed and rectified, it must be distributed by suitable switch gear to the precipitator electrodes. This involves more than meets the eye, especially when one considers the switching combinations required when there are, say, two parallel units and provisions must be made for operating both or either at a given time. Should there be additional units either in parallel or in series, the complications are further extended.

In the past, transformer-rectifier, switchgear, and control cabinets have been located indoors in screened-in spaces, or in specially constructed buildings. Now all of these units can be located out of doors without the need for special protective structures, thus saving space and expense.

The transformer - rectifier and switchgear are commonly located on top of the precipitator and the control cabinet is often located in an indoor area adjacent to other control panels; however, it can be easily modified for NEMA III (weather resistant) requirements.

The control cabinet normally contains a master disconnect switch providing input power to the transformer. It also incorporates a regulator circuit for adjusting the voltage output of the transformer, and start-stop buttons and controls for all associated electrical units used with the precipitator, motors for operating rapping mechanisms that shake the electrode frames and dislodge adhered dust into hoppers, heaters for preventing condensation which may tend to form on high voltage insulators during shutdown, etc.

Most control-cabinet electrical components are standard types

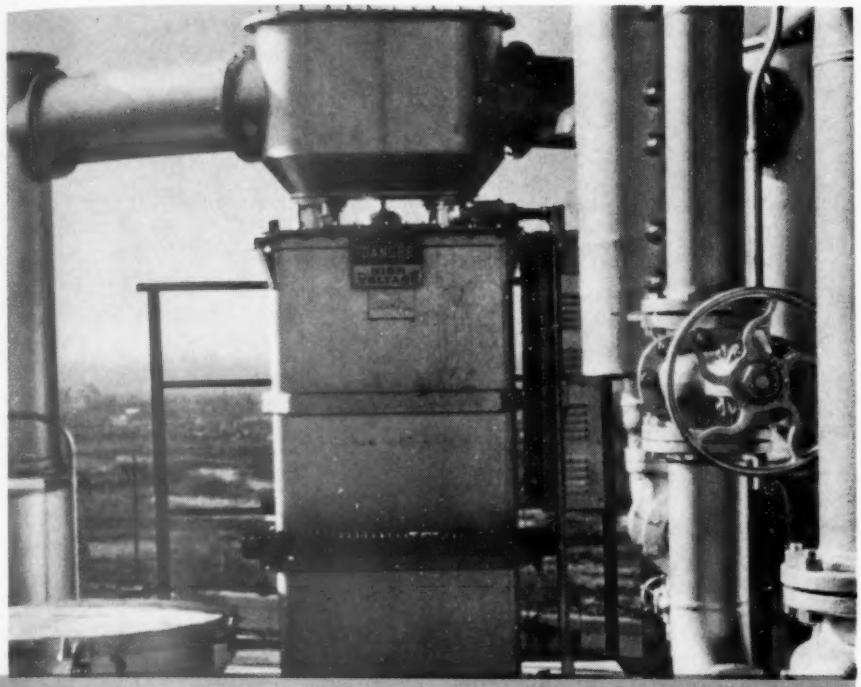


Fig. 3: Immersed-in-oil tube type rectifier atop precipitator saves space. Transformer, rectifier, and high-voltage switch are all contained in one compact unit.

used in other electrically operated equipment and will therefore not be covered in detail here. Nor will the transformer receive detailed attention since there have been very few changes in this item for quite some time. The transformer is always fluid immersed and housed in the same container as the rectifier and/or high voltage switchgear in most modern installations.

Rectification Equipment

However, in the area of rectification, there is a wider choice of equipment. There are four types of rectifiers associated with precipitators — mechanical, electronic tube, selenium, and silicon types.

The mechanical type (Fig. 1), in which appropriately wired disc-mounted contacts are rotated to successively engage stationary transformer and output terminals, is operated in air and is now superseded by the newer types and designs. Its drawbacks were maintenance of the motor, the rotating contacts, and other moving parts.

Also, a comparably large installation space is required due to construction features and it was necessary to house the unit to protect it from the elements (Fig. 2). In addition, it had to be suitably guarded to meet safety standards. Presence of ozone was another drawback.

Tube rectifiers may be of the air cooled or immersed-in-oil types (Fig. 3). In general it is desirable to immerse the tubes in oil in the same container as the transformer. This makes for more compact design by spacing the tubes closer together and by eliminating an extra housing atop the transformer compartment. Saving of space when the transformer-rectifier is located within the plant is, of course, desirable from a dollars and cents point of view. When this equipment is located atop the precipitator, compactness is desirable from the standpoints of space limitations, minimum-weight considerations, and ease of accessibility.

In certain instances, preferential insurance rates are obtained if the transformer is immersed in non-inflammable Askarel oil. The rectifier tubes are not immersed in the fluid but installed in a separate cabinet above the transformer. Askarel fluids are harmful to personnel and though tube changes are infrequent, a separate housing is deemed desirable from a safety standpoint.

During the late 40's a metallic rectifier using selenium as the rectifying element was developed for precipitator use. At first it was believed this type would succeed the tube type and numerous selenium units have been installed. However, after approximately a decade of experience, it has been found that due to such factors as high initial cost, low voltage per diode, doubling of initial power losses, and the bulk size of the selenium units, the tube type is preferable. The fact that the tube rectifier, particularly the immersed type, performs in a most satisfactory manner, has a long tube life, and requires little maintenance, results in tube unit cost curves that have proven in the long run to be lower than those of its supposed successor.

Silicon Rectifier

In the precipitator field the latest rectifier development is the silicon rectifier (Fig. 4). The silicon rectifier is also immersed in a fluid and in the same compartment as the transformer. Although the same reservations pertain to silicon as to tube rectifiers with regard to Askarel, they are less binding since maintenance is very infrequent, the intervals being in terms of years.

It now seems apparent that silicon does not possess the aging characteristics and space requirements of selenium. What seems even more promising, is the fact that extremely high voltages per diode element appear to be a definite future certainty. It is quite

(Please turn to page 43)

Fig. 4: Silicon rectifiers are most modern type. They are highly efficient, extremely compact, and virtually maintenance free. Photo courtesy Westinghouse Electric Corporation.

From Full Factory Air Conditioning, Sylvania Gets . . .

30% Return On Cooling Investment, 7% More Production 50% Less Absenteeism

From a 190,000 sq. ft. plant manufacturing 2½ million radio tubes per month: specific data on humidity, static electricity and corrosion control on high precision work.

by Eugene A. Sloane

IN LAST MONTH'S ISSUE we outlined the economics of factory air conditioning, and how, through proper accounting procedures, profits from the cooling system could be forecast.

With this description of air conditioning at Sylvania we start the first of three articles on how factory cooling has actually paid off.

Because Sylvania found *after* installing air conditioning in its Shawnee, Okla. and Burlington, Iowa tube plants that production stepped up 7 per cent, absenteeism dropped about 50 per cent and quality went up, their air engineers decided to completely air condition the entirely new plant at Altoona, Pa. right from the start.

This 190,000 sq. ft. plant produces 2½-million radio tubes per month. It's built against a hillside, has two levels, the upper of which contains main manufacturing (Fig. 1) and office areas. The lower level consists of storage rooms, boiler and machinery rooms and the plant cafeteria.

The entire manufacturing area is air conditioned, with design conditions at 77°F at 45 per cent relative humidity.

Humidity control is vital in the manufacturing process for several reasons. First, it must be low enough to prevent corrosion of precision manufacturing equipment, which must hold to tolerances to .0002 in. or less, and second, because in high voltage areas humidity caused sweating on metal parts which can cause hazardous electrical short circuits. High potential probes are used to test tube circuits, and high humidity at these stations would constitute a worker hazard.

In addition, static electricity control is a problem, particularly in winter, so moisture must be added to keep humidity at or close to dew point to eliminate static electricity in areas where acetones, petroleum-ether and other highly volatile liquids are used in the manufacturing process.

Tubes are easily contaminated by salts and perspiration, so summer humidity control is important.

Another humidity controlled area keeps tubes from being contaminated by acid. Radio tubes, for example, with 50 ft. of stem machines, which use SO_2 as a lubricant in molding glass, became contaminated when some SO_2 combines with moisture in the air to form an acid. The acid destroys or weakens electron-emitting capacity of the tubes.

Because many of the radio tube manufacturing processes involve high temperature baking, glass melting and heat treating, some of which are combined with the use

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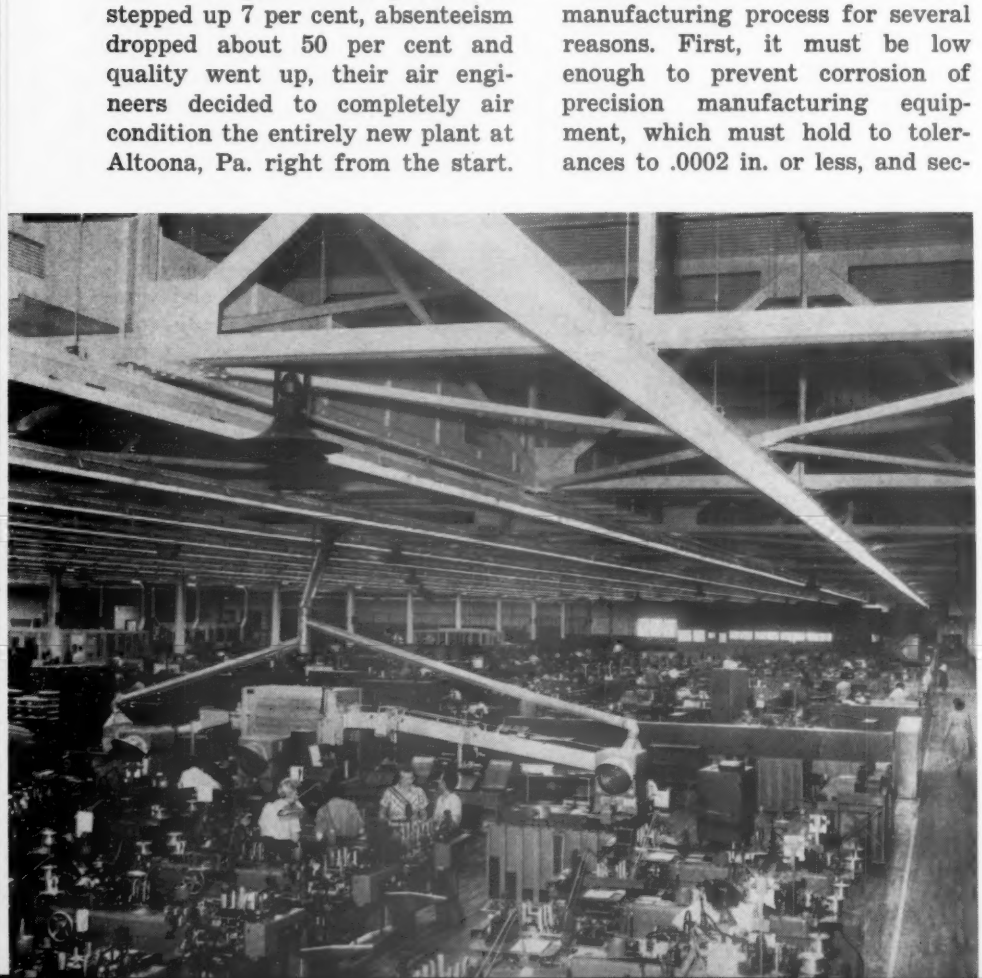

← Fig. 1: Main 200 x 400 ft. manufacturing area. Central air handling stations deliver 275,000 cfm of air through system of ceiling-mounted distribution ducts.

of hazardous gases, local ventilation with hoods is vital. Wherever hoods are used for local ventilation, two dampers are provided. One damper is for balancing the exhaust system, the other shut-off when the machine is not in use.

Equipment requiring ventilation and associated duct hooding are grouped within the plant so that air flow is from outside the department, to the ventilated machines and to collectors or to atmosphere. Excess heat and contaminated air from these processes are removed by exhaust units on the roof, at far less cost than the heat alone could be removed by cooled air. Hence loss of conditioned air from other plant areas is considered to be negligible in terms of what it would cost to cool these "hot spots" by air conditioning alone.

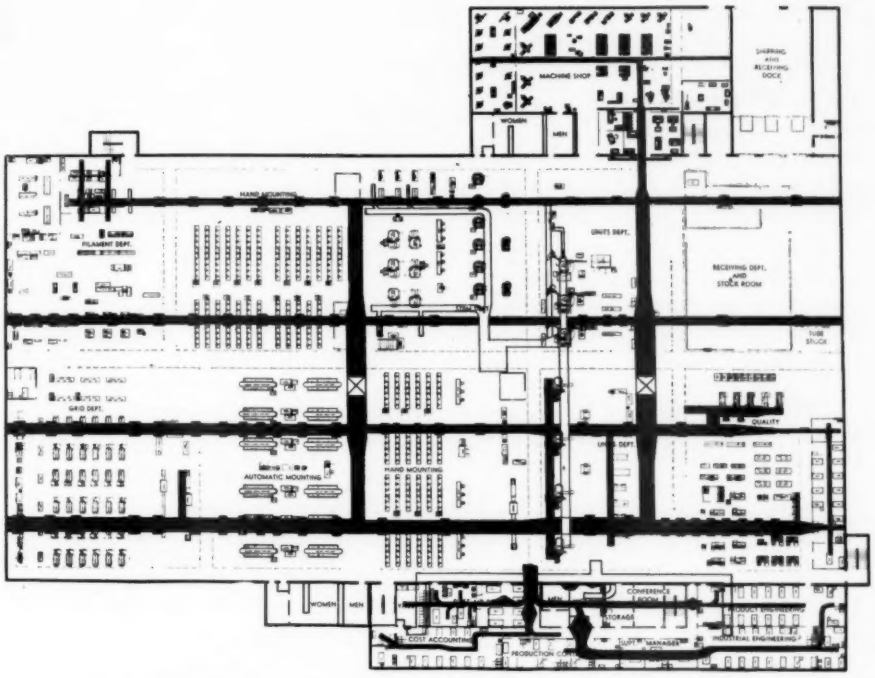

Fig. 1A: Schematic drawing of air conditioning duct layout of the manufacturing area at Sylvania's New Altoona Plant.

Bulb and Stem Dep't.

The stem of the radio tube provides parts for the glass tube and the base. By use of gas, air and oxygen fires, the glass ring is melted about the leads. Air jets control header strains so header and glass tube expand at same rate. This operation is so important that inspection of each part is done on a 100 per cent basis.

The header goes to a cutting and bending machine, where inner leads are bent to predetermined positions controlled to thousandths of an inch.

Thus heat and contaminated air must be removed from the stem machines, and air conditioning used to provide constant temperature and humidity conditions for accurate lead positioning on automatic equipment.

Filament Department

Heater and cathode are made in the filament department. The heater is made by coating pure tungsten wire with aluminum oxide. Wire is first cleaned by passing through a high temperature furnace in a hydrogen atmosphere.

Cathode is made by coating metallic tubular sleeve by means of an automatic spray machine which sprays a mixture of barium, strontium and calcium carbonates in a lacquer suspension. Sleeves are loaded on racks which transport past spray guns (Fig. 3).

Because the exact amount of spray coating is important, the filament spray room is held at 25 to 30 per cent relative humidity. The proper humidity permits the correct atomization of the spray. This room is sealed off from the rest of the plant, the spray machine has its own ventilation system, and the room is held under positive pressure.

Air conditioning is supplied by a separate 50-ton capacity system, with a 3700 cfm air handling unit. Air handling unit has two air intakes, one for outside air make-up during winter, which is provided with a heating coil, the other takes in plant air during summer for make-up.

Grid Department

The grids for the radio tubes are made of fine wires from .006 in. to .005 in. in diameter. Grids are formed on specially designed automatic machines in which two heavy support rods are spirally wrapped with many turns of fine wire. In this operation lateral pitch of winding operation must be held to close tolerance, which is aided by temperature control air conditioning.

After a quality check, grids are degreased in trichlorethylene, then fired at high temperature in a furnace having a reducing atmosphere.

Automatic Mounting

An ingenious Sylvania-designed machine automatically assembles the many tube components. Spacing between components in many of these miniaturized tubes is often held to less than .00002 in. Temperature and humidity control in the area of the auto mount machine is vital to maintenance of these extremely fine tolerances.

Many of the electrical characteristics of the tube depend on exact spacing of mica insulators, cathode, control and screen grids, plate and beam plate.

The automatic assembler spews out tubes at the rate of 1500 to 1800 assemblies per hour.

Units Department

The finished mount assembly, and the bulb, are sealed and exhausted in the unit department, on a machine known as a double turret sealex.

Dust control is important in all departments, and especially vital in this last step before tube components are glass covered. Lint or other foreign matter between grids, for instance, would be carbonized by heat and would short out the tube, causing a reject.

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Make-up air for the plant area is furnished by two roof-mounted air washers supplying 275,000 cfm. Local exhaust air systems serve individual machines which are a source of heat or contaminated air, the cafeteria, lavatories and infirmary.

The air conditioning systems use a ratio of 25 per cent outside air to 75 per cent return air during the summer.

Here is a case where previous profitable experience with air conditioning proved that it would pay off in a new plant. Accurate cost studies can take the place of previous experience, as shown last month in the article on Factory Air Conditioning, p. 20. ▲▲

CREDITS

All air handlers, refrigeration compressors furnished by *Carrier Air Conditioning Co.*

Architectural and engineering work on new building by *Facilities Planning Division of Sylvania Electric Products, Inc.*

Fig. 2: Steam machines, heat and fumes are vented through air hoods. Ductwork is connected to a common header leading to roof-top exhaust air fan.

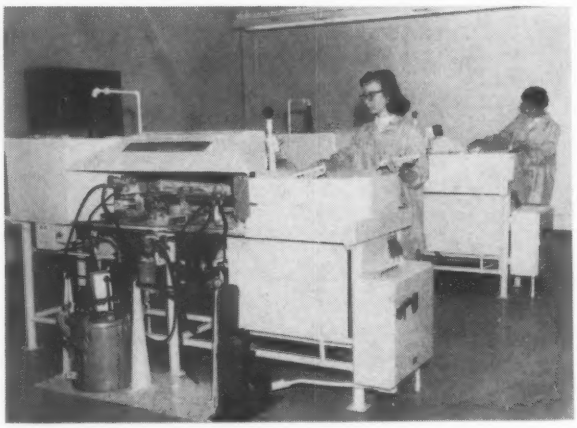

Fig. 3: In filament coating room, humidity is held at 25 to 30% with separate air conditioning system. Air pressure is kept higher, so air goes out, not in, when doors are open.

"He said he has been in your office before."
C. H. Smith, The Kroger Co., Cincinnati, Ohio

Last month we offered $5.00 for the best caption to the cartoon above. In our opinion, the caption given by Mr. Smith is the best submitted. However, many of the others sent to us were also quite humorous and we take pleasure in listing them here as worthy of your perusal. While Mr. Smith has won the "grand" prize, we hope the Honorable Mention will be some reward for having sent in the captions.

"Mr. Hayes from the West Coast to see you."
Lloyd E. Gordon, Director, Industrial Hygiene Zurich Instruance Company, Chicago, Ill.

"That know-it-all filter salesman is back again."
Kevin J. Higgins, Sales Engineer, Johnson Service Company, Columbus, Ohio

"He says he's your best friend."
H. B. Minturn, mechanical engineering supt., Ormet Corp., Hannibal, Ohio

"It was his idea, Mr. Leader."
C. W. Lees, Jr., plant engineer, Bell Telephone Laboratories

"I think our ventilating consultant wants to discuss the condition of our building."
H. R. Lopez, U.S. Naval Research Laboratory Washington, D. C.

"Your new planetary division manager has just arrived."
J. J. Hagemeyer, Bethlehem Steel Co.

Purchasing agent saying: "What dusty problem?"
Frank Herbison, Columbus, Ohio

Girl to air pollution control officer: "I believe this man would like to register a complaint."
Robert L. Carney, Air Pollution Control, Wheeling, W. Va.

Plastic Fibers As Panel Air Filter Media

by Air Filter Institute

Above: Glass fiber filter of automatic self-cleaning type with performance of viscous type. Photo American Air Filter Co., Inc. This is not the electrostatic type of filter.

Editor's Note:

Because the Air Filter Institute represents many of the filter and filter media suppliers in this country, we publish this organization's statements about plastic fiber filters.

We would also be most happy to publish the statements of those who disagree with the Air Filter Institute's evaluation of the filter efficiency of plastic fiber filters.

CERTAIN PLASTIC MATERIALS such as polyethylene, polystyrene, Mylar, and others exhibit unusual electrostatic properties. These properties are described in detail by P. C. Woodland and E. E. Ziegler, "Static Dust Collection of Plastics," 1951, sponsored by Dow Chemical Company.

Of most interest to the air cleaning industry is that under certain conditions the surfaces of these plastic materials may achieve patch charges at relatively high potentials such as 5000 to 10,000 volts.

Patch Charges

It might be supposed that these patch charges, or the electrostatic fields resulting from them, could be harnessed to enhance the dust removal ability of these plastic fibers. However, no evidence has been found to support this supposition, either at normal panel filter velocities or at velocities as low as 5 to 10 percent of normal velocities observed in practice. It is evident that whatever electrostatic characteristics may prevail in plastic materials, these characteristics are not useful in cleaning air.

Another characteristic of these plastic materials is that damp or humid dust particles will not adhere to charged plastic surfaces. Moreover a moisture layer over the plastic surface will "shield" and nullify the charge influence. As far as is known, all destaticizers employ the action of coating surfaces with hygroscopic material so that moisture from the air creates a thin conducting layer.

Before describing tests made on the dust removal ability of plastic fibers, it is necessary to discuss means for detecting the presence of patch charges. The potentials of the patch charges inherent in plastic materials cannot be measured by conventional electrostatic voltmeters or electrometers. Electron availability from these charges is insufficient to activate a measuring instrument of this type.

However, the Dow Chemical Company developed two specially prepared fluorescent powders. The red powder has an affinity toward a negative charge, and the green powder has an affinity toward a positive charge. These powders may be thoroughly mixed and then sprinkled over plastic surfaces or fibers. If the plastic surfaces possess any appreciable patch charge, a very pronounced separation of the two powders indicates the exact pattern of the positive and negative areas. Failure of separation to occur indicates the absence of electrostatic charge.

AFI Experiments

Many tests and experiments have been carried out by Air Filter Institute member laboratories to establish the performance characteristics of various plastic air filter mats. The tests described below are typical and the results listed agree with those of other investigations not described here.

During May, 1958, one of the Air Filter Institute

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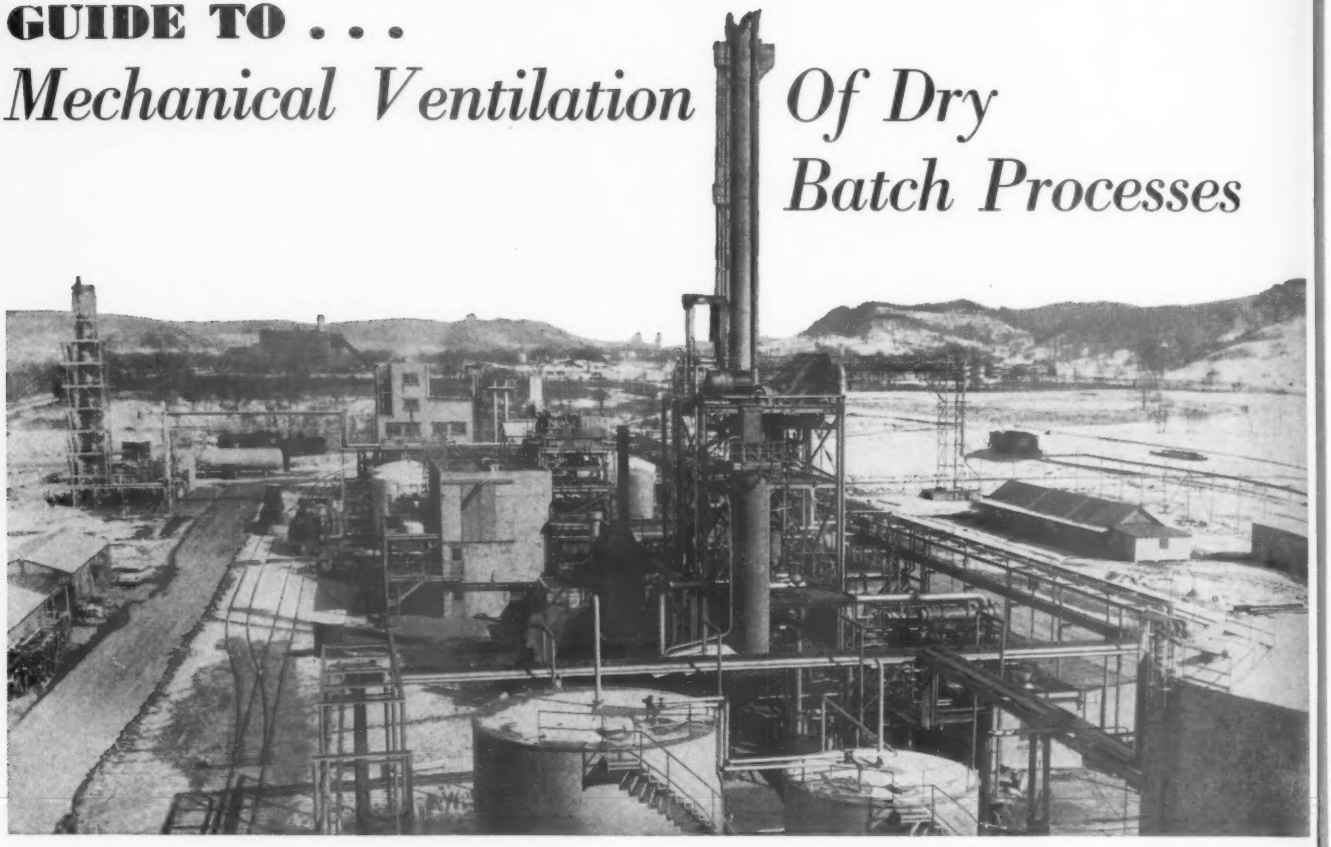
GUIDE TO . . .
Mechanical Ventilation Of Dry Batch Processes



View of American Cyanamid Co.'s new aniline manufacturing facilities at Willow Island, W. Va. Plants such as these require careful design of ventilating systems to maintain employee health.

By William V. Andresen
Chief Industrial Hygienist
American Cyanamid Co.

Complete data for ventilation of batch tray type dryers, including loading, drying, and dumping operations.

IN THE CHEMICAL INDUSTRY, wet solids which have been filtered in batch equipment as filter presses, Nutsche filters and basket centrifuges are often dried in batch drying equipment.

The batch dryer most commonly used for these drying operations is the tray type dryer. This consists of an insulated enclosure containing fans and heating coils for the circulation of heated air.

Tray dryers may be of the tray truck or stationary tray design. Trays are loaded into trucks in the tray truck dryer operations and the trucks are rolled into the dryer. In the stationary tray design, the trays are inserted into the racks permanently installed within the dryer.

For the purpose of this article, the following operations to constitute the drying operations:

- Loading of dryer trays
- Drying
- Dumping of dryer trays

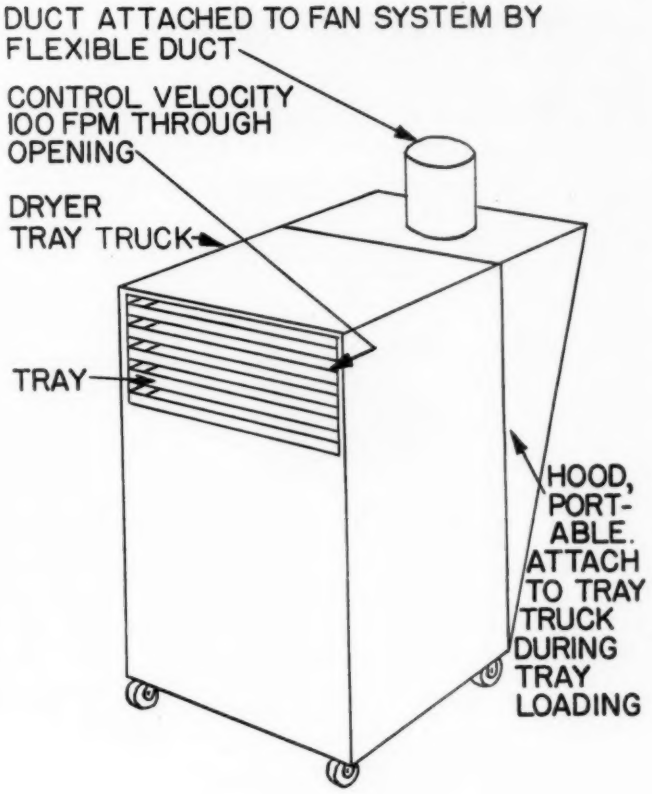
Employees may be exposed to toxic or irritating materials during the tray loading operation. The product to be dried may itself be toxic or irritating or the filter cake may contain residual liquids which might produce toxic or irritating gases or vapors.

Since this article specifically describes ventilation for control of gases, dusts and vapors, the use of protective clothing and equipment will not be discussed.

In a previous article (October, 1960, AIR ENGINEERING) "Ventilation for Vacuum Dryers Batch and Continuous," ventilation for the loading of dryer trays directly from a Nutsche filter was described. It was indicated that additional ventilation for the dryer truck might be required for control of toxic or irritating gases and vapors. Sketch #1 shows the design of a portable hood which may be used for control purposes. When in use, the hood is attached to the mechanical exhaust system by a flexible duct

WILLIAM ANDRESEN is chief industrial hygienist for the American Cyanamid Co. A graduate engineer, he is vice chairman of the Bergen County, New Jersey air pollution control committee. He is also a delegate from the National Safety Council to the American Standards Association committee Z-9 on industrial ventilation. He is a member of the American Industrial Hygiene Association.

Fig. 1: Portable tray truck hood. Control air volume is drawn through openings between trays. A control volume of 100 fpm will provide satisfactory control. →


DUCT ATTACHED TO FAN SYSTEM BY FLEXIBLE DUCT
CONTROL VELOCITY 100 FPM THROUGH OPENING
DRYER TRAY TRUCK
TRAY
HOOD, PORTABLE. ATTACH TO TRAY TRUCK DURING TRAY LOADING

connection. A control velocity of 100 fpm across the open area between trays will usually provide satisfactory control.

Trays for tray or tray truck dryers are often loaded from tote boxes or drums. Sketch #2 shows a hood design which has been successfully used to control vapors liberated during tray loading and the insertion of the trays into a truck. A control velocity of 100 fpm across the hood open face will usually provide satisfactory control. The tote box or drum of product to be loaded into trays is contained within the hood and shoveled or scooped into the dryer trays which are then inserted into the dryer truck.

Sketch #3 shows an alternate design of a hood enclosure for the control of gas or vapor liberated during the loading of drying pans. This particular design is usually used to load trays which are inserted directly into a tray dryer rather than into trucks. A hood face velocity of 100 fpm will usually provide satisfactory control.

The mechanical exhaust ventilation for the tray loading hoods may be supplied by centrifugal or axial flow fans.

The drying operation itself seldom presents a serious problem. Control of the gases and vapors liberated in batch drying operations can be accomplished by maintaining a slight negative pressure on the dryer or by maintaining a good seal on the dryer doors.

The removal of the dried product from the dryer

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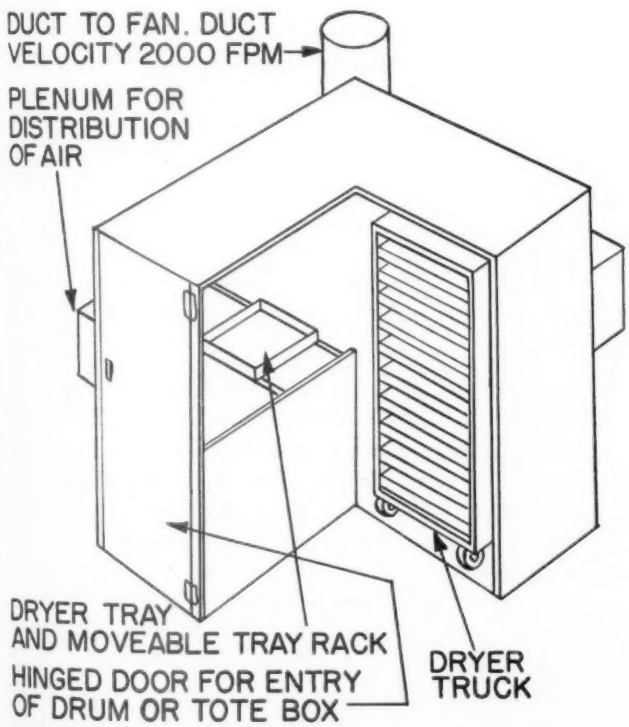

DUCT TO FAN. DUCT VELOCITY 2000 FPM
PLENUM FOR DISTRIBUTION OF AIR
DRYER TRAY AND MOVEABLE TRAY RACK
HINGED DOOR FOR ENTRY OF DRUM OR TOTE BOX
DRYER TRUCK

Fig. 2: Typical dryer tray loading station for the control of residual vapors from material to be loaded into trays for drying.

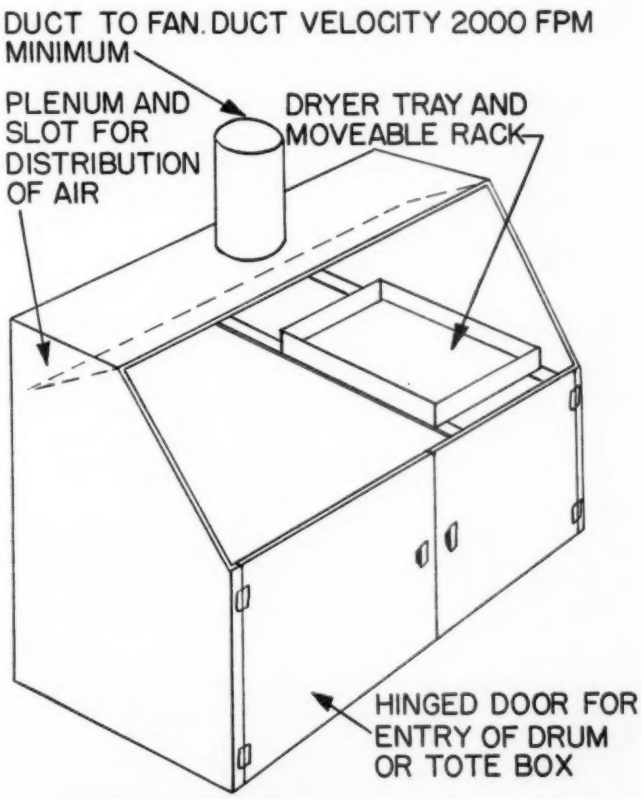

DUCT TO FAN. DUCT VELOCITY 2000 FPM MINIMUM
PLENUM AND SLOT FOR DISTRIBUTION OF AIR
DRYER TRAY AND MOVEABLE RACK
HINGED DOOR FOR ENTRY OF DRUM OR TOTE BOX

Fig. 3: Alternate design of dryer tray loading station for the control of residual vapors from material to be loaded into trays for drying.

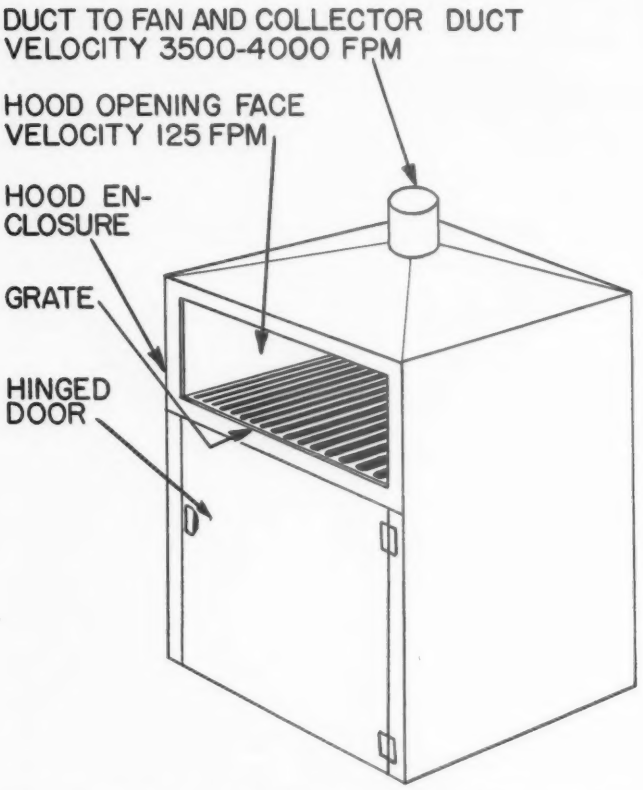
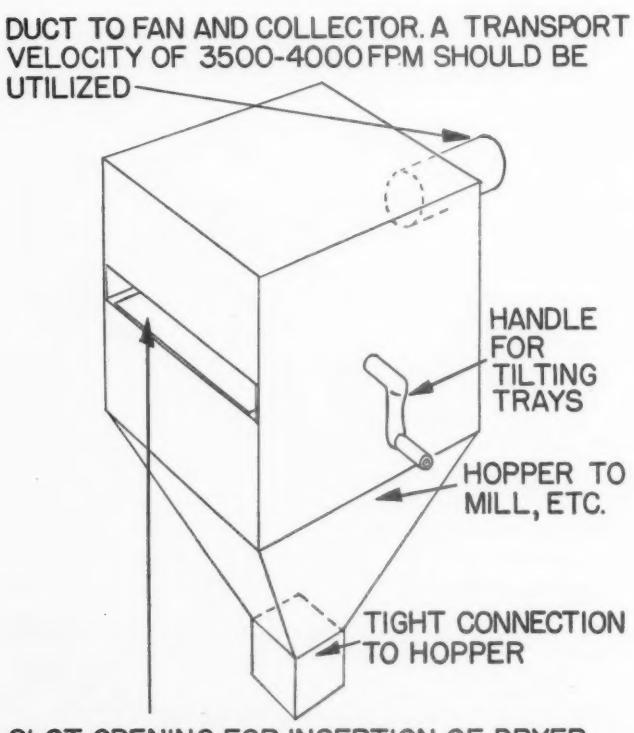

DUCT TO FAN AND COLLECTOR DUCT VELOCITY 3500-4000 FPM
HOOD OPENING FACE VELOCITY 125 FPM
HOOD EN-CLOSURE
GRATE
HINGED DOOR

Fig. 4: Typical tray dumper hood. Used with unit collector. The dryer trays are upended inside hood and the material is collected in drums in bottom of enclosure.

trays may present a problem of employee exposure to toxic or irritating dusts. Dust can be controlled by mechanically exhausted tray dumping hoods.


DUCT TO FAN AND COLLECTOR. A TRANSPORT VELOCITY OF 3500-4000 FPM SHOULD BE UTILIZED
HANDLE FOR TILTING TRAYS
HOPPER TO MILL, ETC.
TIGHT CONNECTION TO HOPPER
SLOT OPENING FOR INSERTION OF DRYER TRAYS. A CONTROL VELOCITY OF 125 FPM SHOULD BE MAINTAINED THROUGH OPENING.

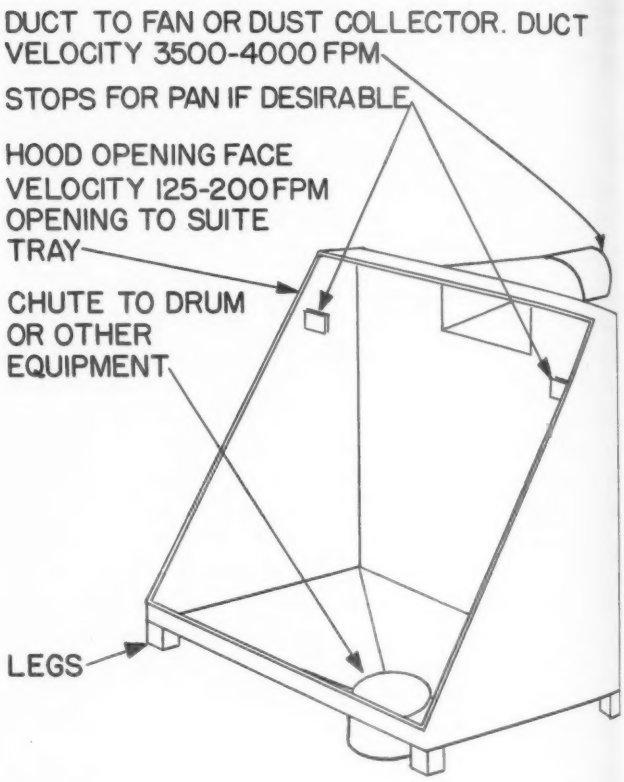

DUCT TO FAN OR DUST COLLECTOR. DUCT VELOCITY 3500-4000 FPM
STOPS FOR PAN IF DESIRABLE
HOOD OPENING FACE VELOCITY 125-200 FPM
OPENING TO SUITE TRAY
CHUTE TO DRUM OR OTHER EQUIPMENT
LEGS

Fig. 5: Tray dumper design. Chute may be attached to drum by canvas connector or enclosure or slot ventilation utilized. Design is desirable with large heavy trays.

Sketch #4 shows the design of one type of tray dumping hood which has been used successfully for control of dust during tray dumping operations. The tray is inserted inside of the hood and upended manually. As shown in the sketch, the dumped product may be collected in drums within the tray dumper enclosure. The tray dumper may also be adapted to discharge material directly into hoppers or process equipment such as crushers and pulverizers. Satisfactory dust control can usually be realized by a hood face velocity of 125 fpm.

Sketch #5 shows another design of a manual type tray dumping hood. In operations with this hood, the dryer tray is placed on the edge of the hood and upended into the hood. This particular design is suited to large heavy trays. A velocity of 125 fpm will usually provide satisfactory control.

Sketch #6 shows a dryer tray dumper in which the dryer tray is turned over mechanically by a handle. The dryer tray is inserted into a small opening onto an angle frame. A control velocity of 125 fpm through the hood opening will usually provide satisfactory control.

The dryer pan dumpers are usually connected to dust collectors. ▲▲

Fig. 6: Tilting type tray dumper. Pan is inserted in angle frame and is turned completely using handle. Design shown for dumping dried material into mill hopper and may be altered for dumping into bins or drums.

New Literature

"Ultra Clean Packaged Environments"

A brochure detailing the Moore & Hanks Company packaged white rooms, incorporating temperature control of $\pm\frac{1}{2}°F$, humidity control to ± 2 per cent relative, and airborne contaminants to 0.5 microns removed.

The other advantages listed in this bulletin are: more efficient than conventional construction; less expensive than converting existing buildings; not a fixed improvement and it may be moved; used in major military installations.

Circle #100 on page 51.

Automatic Particle Counter and Sizer

The new Cassella automatic particle counting and sizing apparatus is described in a 13-page brochure issued by Cooke, Troughton & Simms, Inc. The brochure lists the Cassella's specifications, general description, theory of counting and sizing, instrumentation, and sizing by variable slits.

The Cassella is applicable to any substance in discrete small particles in the range from 1 through 200 microns; diamond dust, ascite tumor cells, insoluble fluid contaminants, spray droplets, chemical powders, etc.

Circle #101 on page 51

"Making Sound Behave"

The Barber-Colman Company has prepared a sound slide film entitled "Making Sound Behave."

Important facts for engineers and architects about air distribution sound levels are discussed in this new sound slide film. Decibel variations and air distribution sounds of different frequencies have been recorded for this interesting and educational presentation.

A booklet telling the story of the film, complete with pictures, is available.

Circle #102 on page 51.

Flexible Exhaust Hose and Duct Bulletin

The Flexaust Company has issued a new bulletin on their line of Flexaust® Hose and Duct. The hose is made of cotton drill, nylon duct or glass fabric with a spiral steel wire reinforcement. It is used for moving air, dust, fumes and materials, via pressure, suction or gravity.

Listed in the bulletin are: material specifications and construction of standard types; industrial prices per foot; accessories pictured with a short description and price listings; installation data and complete information, including specifications and price listings, of the Portovent® Duct.

Circle #103 on page 51.

Electric Locking Devices For White Rooms

A bulletin describing and illustrating Challenger Lock Company's electric remote locking and unlocking devices for safety electric door locks, communicating locks and light or air trap locks, all applicable in the white room area or similar areas where safety locks are necessary.

Circle #104 on page 51.

"Steam Heating Coils"

A new booklet is available from the Westinghouse Electric Corporation. The 24-page publication includes application information on blast heating coils, distributing tube heating coils, and dual feed distributing coils. It is complete with many photographs and drawings and contains sections on construction details, selection, performance, piping diagrams, and installation procedures.

The booklet describes the wide range of sizes and capacities of steam heating coils available and should be particularly interesting to architects, consulting engineers, and industrial plant and process engineers.

Circle #105 on page 51.

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? ? ? ? ? ? ? *Questions & ANSWERS* ? ? ? ? ? ? ?

White Room Design And Operation

A late evening bull session at the Symposium on White Rooms at the University of Arizona produced a string of interesting questions on white room design and operation.

In the January AIR ENGINEERING we offered readers who designed, built, and/or operated white rooms $25.00 for the best set of answers to the questions posed below. We offer the first set of answers from Mr. E. P. Coughlin, Project Engineer, Plant Engineering Dept., Continental-Diamond Fibre Corp., Newark, Delaware.

The Questions On White Room Design And Operation

1. What is the preferred method of running utilities (air, electrical etc.) in white room areas in order to provide maximum flexibility for future layout changes?

2. Has anyone used suspended floor construction to provide crawl space for utilities distribution?

3. How satisfactory is translucent plastic ceiling with light fixtures and sprinkler heads suspended above?

4. Could plastic material be used with the "Air-Son" type of air distribution?

5. What is most satisfactory material for floor and walls for use with chlorothene and cobehn solvents?

6. What has been found to be the most satisfactory general lighting intensity for bench assembly *without* local lighting. What is the best ratio of lighting intensities when using both local and general lighting?

7. What is the latest equipment for dust particle monitoring? I believe we would prefer a continuous monitoring system to reflect changing rather than the sampling type of system.

8. What is the most satisfactory type of air distribution? Are ducts preferred over the bleedout system where air is left to escape under door openings?

9. How many companies use music in their plants, particularly in the white room areas? Are intercom systems in white areas considered a basic necessity?

10. a. What is the preferred height for outside window viewing?

b. What is the preferred ceiling height?

11. What bench design is preferred?

12. a. What is the preferred method for cleaning white areas (vacuuming, damp mopping, or other)?

b. Are static collectors used to concentrate any local dust collection?

c. I would like to see a general consensus of opinion on the most efficient air filtering system in use today.

13. Are built-in storage facilities used in white areas and who makes such equipment?

14. Are there any particular personnel problems that companies have encountered in the operation of white rooms?

Mr. Coughlin's Answers To White Room Questions

1. All utilities are installed in the walls with a multiplicity of connections to eliminate the need for future disruption for new requirements.

2. Suspended floor construction not used.

3. Not known.

4. Not known.

5. Not known.

6. General lighting in assembly and inspection areas: 120-140 fc. Local lighting for critical assembly: 200 fc.

7. Not known.

8. Definitely ductwork.

9. Music used in plant but not in "white room" area. Intercom definitely needed in "white room" areas due to tight control of personnel movement.

10.(a) Three and ½ feet found to be satisfactory. (b) Nine feet found to be satisfactory.

11. Formica covered with back coving and preferably wall mounted.

12.(a) Continuous vacuum cleaning with full-time janitorial service. (b) No. (c) Series installation of fibre glass filters, electrostatic, and absolute filters in that order.

13. Not known.

14. Most serious problem results from union "seniority-bumping" procedure. Most "white rooms" are relatively new with resulting new employees. During "slow periods" in other parts of the shop, personnel with more seniority will "bump" trained "white-room" personnel. When this occurs there is a definite increase in contamination consistent with the number of new employees. This is very serious in that it may take a week for the new employees to become familiar with good "white room" policy. In the case where the "bumping" occurs for a few months, the "white room" will be operating far above the maximum contamination level for this entire period.

How To Control Oil In Plant Air?

We have a problem with oil in plant air. The air is compressed to 40 psig with a rotary compressor, passed through an oil separator, carbon filter and dehumidifier. I have found no traces of oil in the storage tank or discharge piping, but I have found condensation in instruments. Have you any suggestions?

W.A.H
West Virginia

Answer

Without knowing the full detail of the system operation there appears to be several reasons for the oil in the air. It is assumed from the brief information given that the air after going through the oil separator, carbon filter, electro dryer and dehumidifier is discharged into a space where it condenses or settles on instruments.

First it is possible that the oil which causes the contamination is of extremely small particulate size so that it passes through the oil

Precipitator Electrical Requirements

(Continued from page 33)

foreseeable that a complete rectifier unit will ultimately be of such a size to be encapsulated in a solid form of insulating material. The entire rectifier unit will be plug-connected to both the transformer secondary terminals and the supply terminals of the distribution switchgear.

Should these terminals be in the form of epoxy insulators, the ultimate size of the transformer-rectifier would be limited only by the size of the transformer. It is further conceivable that improvements in the field of transformer design could result in a completely capsulated transformer - rectifier unit in which the capsulating material would not only be the insulation but also the case of the unit.

In the May Issue of AIR ENGINEERING, *Mr. L. L. Nagel will discuss the selection of switchgear, emitting frames, and instrumentation for precipitator equipment.*

Questions & ANSWERS

(Continued from preceding page)

separator and carbon filter and does not settle out in the piping. This can take place as oil separators are not always efficient against small droplets of oil. The presence of oil in the particulate phase could be readily determined by passing the compressed air through one of the ultra efficient membrane filters such as millipore and examining it for the presence of oil. If this is the case, more efficient filtration would be the answer.

The second possibility is the oil is in the vapor phase and is unaffected by the oil separator, and carbon filter. (However, if the dehumidifier were of the cooling type condensation should take place).

If the compressed air is discharged with a drop in pressure from 40 psi to atmospheric pressure cooling of the air stream will take place, which may be sufficient to convert the oil in vapor phase to a liquid state where droplets are formed. The presence of oil in the vapor phase could be readily ascertained by the use of a low temperature freeze-out trap such as is used to sample vapor contaminants in air pollution studies. The compressed air should be passed through the freeze-out trap using ice, or dry ice as a cooling media; if oil were present in the trap further cooling of the compressed air stream could be used to remove oil in the vapor phase.

Wants More Information On Expelling Coal Dust

Your January issue contains an article entitled, "Coal Dust Expelled by French Methods," which is of intense interest to us. Can you favor us with additional information or direct us to a source where we can obtain same?

We use -10 mesh coal in our plant and control our dust extremely well with a spray application at the unloading station. However, at the point of unloading there is insufficient time for our wetting agent to take control and we enjoy severe dusting at this point. Spraying at the mine has proved unsatisfactory due to the coal absorbing the wetting agent before we unload at the plant.

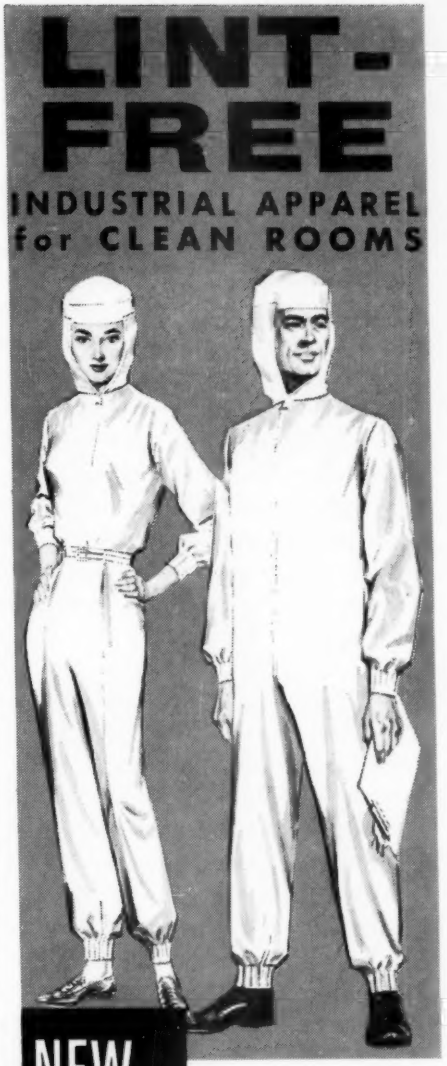
W.A.G.

Answer

The short piece, "Coal Dust Expelled by French Method," was supplied by one of our correspondents from a European source.

However, by checking with the local sales office of the Solvay Company, we believe that the French approach was probably based on the application of calcium chloride.

The local office of Solvay promised to advise their Chicago office of your interest, so you may be hearing from them soon.



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How To Handle Corrosive Gases

(Continued from page 30)

Thus, a duct may be fabricated from a sheet and the seam welded. One supplier of polyethylene fabrications centrifugally casts his PE ducts. Seamless, these ducts are more costly but preclude stress cracking at welds, where such cracking most frequently occurs.

ABS, so far, has to be solvent welded, cemented, rather than heat welded. This is a cheaper joining methods, but one which proves unreliable in the hands of inexperienced workmen. Too, solvent welding of piping, with well matched tube-and-socket joints, is much simpler than working with ductwork which frequently requires two men.

Cemented joints in ABS tend to develop leaks; welded polyethylene joints tend to stress crack; PVC tends to cold flow. Such factors must be considered in design of the system. As indicated earlier, the plastics industry is developing a valid core of engineering knowledge upon which plant engineers and others can draw for help with specific fume handling problems. The manufacturers involved and the two or three plastics associations and societies have, for the asking, much specific data on physical, chemical, structural, engineering properties of the common and newer plastics.

After fumes are removed from the work or process area, something other than dumping them into the atmosphere must be done with them. Hence, the need for air washers and fume scrubbers. These, too, are fabricated from the same materials already discussed. There are scrubbers constructed chiefly of stoneware, of steel and plastic, of plastic alone.

Contaminated air passes through several stages of water washing until most contaminants are dissolved or absorbed and the air, 99+ percent pure, passes out. In some cases, the air is recirculated rather than exhaust, a procedure which has the added advantage of saving heat from the structure. Contaminated water from these scrubbers may be wasted or treated before dumping. A few municipalities prefer some acid content in waste waters to neutralize detergents in water which are disrupting the effectiveness of sewage treatment plants. ▲▲

CORROSION RESISTANCE CHART

Now available, a *Corrosion Resistance Comparison Chart* including PVC Normal, PVC High Imp., Styrene Butadiene, Polyeth., and Neoprene from 72F to 140F for 162 chemicals.

To receive a copy of the chart circle #97 on the postage free card on page 51.

Plastic Fiber Air Filter Media

(Continued from page 37)

member laboratories conducted tests using a very dense plastic fiber medium with fiber diameters in the range of 1 to 5 microns. A single ply filter mat, ⅛ in. thick, exhibited a high degree of inherent electric charge as determined by the fluorescent powder technique.

Atmospheric Dust

This media was mounted as a panel filter in a duct, and tested by the National Bureau of Standards Dust Spot Method at various velocities down to 25 fpm. Only outdoor atmospheric dust was used as a source of contaminant and this same medium was then discharged by spraying with a destaticizer fluid. It was then thoroughly dried and retested. The same test procedures revealed the *same* efficiency with completely discharged fibers as was found previously when the mat demonstrated a high degree of patch charge. Again the powder technique was used to establish beyond doubt the absence of charge after the destaticizing treatment. This showed conclusively that the electrostatic patch charges present had no effect on the dust removal ability of the mat.

"Self-Charging" Type Filter

In April, 1957, the Air Filter Institute through a member laboratory completed an investigation of the plastic "self-charging" type filter for submission to the Federal Trade Commission. This investigation disclosed that:

1. The average Dust Spot efficiency (using atmospheric dust) of the plastic filter was 4 percent utilizing the inherent static charge. When this filter was discharged by means of polonium strips the average efficiency remained the same at 4 percent. Conventional plate type electronic air cleaners will provide for 90 to 95 percent efficiency under the same test conditions.

2. With alcohol-benzene smoke enriched air, using the National Bureau of Standards test method, the efficiency of the plastic fiber filter was the same untreated as it was treated with polonium to remove any inherent charge. Again the values averaged 4 percent.

These values of 4 percent were obtained on one type of plastic fiber filter. Other types may exhibit higher or lower values depending upon the nature of the mat-fiber size, density, thickness, etc. The point of importance is that the presence of inherent electrostatic charge does not affect the air cleaning ability of the plastic fibrous mats.

We must draw the conclusion from the results of these studies that plastic fiber filters characterized by inherent electrostatic charge or claims thereof do not exhibit any improved collectance efficiency performance as a result of any inherent charge. ▲▲

Air Conditioning At Convair

(Continued from page 25)

To equate the cost to a private ownership situation, annual cost of invested capital, both original cost and expenditures for replacement and modernization must be added. According to construction cost records, the original cost chargeable to the central system, including boilers, cooling water supply, etc. was $5,850,000. Cumulative costs are as follows:

Original investment	$5,850,000
Replace condenser water line	32,000
Rehabilitation—Fiscal year 1957	179,000
Fiscal year 1958	225,000
Fiscal year 1959	210,000
Fiscal year 1960	236,000
Fiscal year 1961	150,000
Total	$6,882,000
Annual cost at 5 percent	$ 344,100
Total cost/employee/year	$58,82
Total cost/direct labor hour (1960)	$ .0471

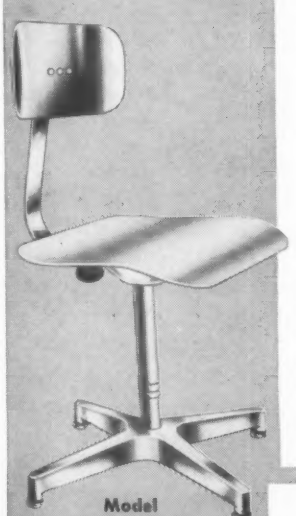
Thus it may be seen that the cost per employee-hour, based on total present employment, is 1.98 or 2.99 cents, or as a burden on direct labor, is 3.18 or 4.71 cents per hour. These costs will vary inversely with number of employees or direct labor hours, respectively.

The existence of the air conditioning system is justified if it increases productivity by less than two percent. *Its less tangible values in employee satisfaction, morale, and product quality are inestimable.* ▲▲

CREDITS

Contracting Agency: *U. S. Army Corps of Engineers*
Architect-Engineer, and General Contractor: *Austin Co.*
Mechanical Contractor: *Wallace Plumbing Co., Dallas*
Electrical Contractor: *Fischbach & Moore, Dallas, Texas*
Boilers—4—100,000 #/hr. @ 250 psi: *Riley Stoker Co.*
Boiler controls: *Bailey Meter Company*
Condensing Units: *Worthington Corp.*
Chilled water pumps: *Worthington Corp.*
Chilled water pump motors: *General Electric Co.*
Allis-Chalmers
Cooling water pumps: *Worthington Corp.*
Cooling water pump motors: *General Electric Co.*
Supply fans: *Buffalo Forge Co.*
Fan motors: *Westinghouse Electric Co.*
Louis Allis Co.
General Electric Co.
Coils: *Aerofin Corp.*
Air filters: *American Air Filter Co., Inc.*
Control system, pneumatic type: *Johnson Service Co.*
Air diffusers: *Barber-Colman Co.*
Switchgear: *General Electric Co.*
Motor Controllers—4160 volt: *General Electric Co.*
Motor Controllers—440 volt: *Allen-Bradley Co.*
Electric Distribution Panels: *Square D Co.*

SPECIAL CHAIRS FOR WHITE ROOMS AND DUST FREE AREAS



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Other White Room chairs with lacquered plywood seat and backrest.

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Bowling Green, Ohio

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This four-page bulletin

describes a new service which provides complete, pre-engineered "clean" or "white" rooms in one package at one price — including installation and employee training. 31 construction and operational details of a typical dust-controlled clean room are illustrated.

Write for your free copy

Controlled Environment, Inc.
52 Pickering Street ◆ Needham 92 ◆ Massachusetts

New PRODUCTS

New Series Of Airfoil Centrifugal Fans

Purpose: The new series has been designed for air supply and exhaust in air conditioning, ventilating, industrial processing or mechanical draft applications.

Features: Designed for slower speed and lower noise levels, the new series catalogs static pressures of ¼ to 30 in. in volumes ranging from 440 cfm to 560,000 cfm and temperatures up to 800°F.

"Design 10" fans are engineered to operate at a low horsepower, permitting the use of smaller motors to reduce power consumption. Hollow airfoil shaped blades provide for quieter operation and increase operating efficiencies.

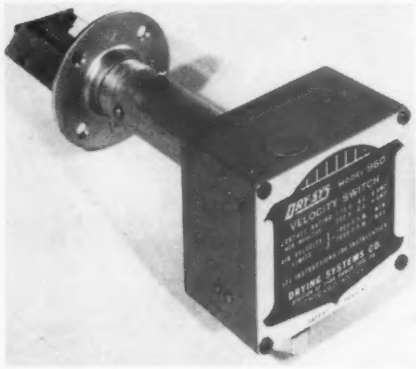
The new fans come in sizes 12½ to 89 and in five classes of construction. Classes I and II will handle static pressures from 5 to 10 in. Classes III, IV, and V will handle static pressures from 15 to 30 in.

Source: Chicago Blower Corp., Franklin Park, Ill.

Circle #50 on page 51.

Protection Against Air Flow Failure

Purpose: A new Velocity Switch that is not actuated by the air velocity in a duct and is not responsive to static pressure or suction.



Features: The Velocity Switch can be mounted at any angle, and operates on either the inlet or discharge side of the fan.

Duct air is unable to pass through the Velocity Switch or external air to pass in the duct through the switch. Primary switch is magnetic, through a solid barrier. The switch responds to velocities as low as 1000 fpm.

Source: Drying Systems Co., Chicago, Ill.

Circle #51 on page 51.

New Styles In White Room Clothing

Purpose: A complete line of "clean room" job-oriented styles for men and women, including coveralls, lab coats, trousers, shirts, dresses, slack sets and caps.

Features: Worklon is introducing a new Dacron blend that is lint-free, static free, and offers good resistance to deterioration by acids and caustics.

Source: Worklon, New York City.

Circle #52 on page 51.

Ceiling Air Distribution System

Purpose: This new low-velocity air distribution system combines a Fiberglas air supply tube with a perforated metal bar diffuser which distributes the air evenly.

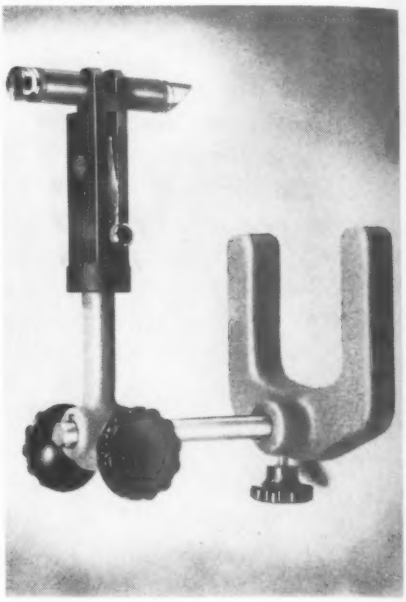
Features: The Fiberglas Acousti-Flo System is a low cost, attractive ceiling installation designed to combine the positive delivery of air through self-insulated tubes with full wall-to-wall diffusion, which is easily controlled by adjusting the continuous dampers.

Source: Owens-Corning Fiberglas Corp., New York City.

Circle #53 on page 51.

Industrial Measuring Microscope

Purpose: For industrial inspection, checking, and quality control.



Features: The 50X Measuring Microscope is sturdily built, inexpensive, and measures to 1/1000 in. It has rack and pinion focusing with a 7 in. rack. Arm is 8 in. long and base can be adjusted through a full 360° so that it will not interfere with long or irregularly shaped subjects. Reticle is calibrated to measure 1/10 in. by .001 in. divisions. Priced at $19.75.

Source: Edmund Scientific Co., Barrington, N. J.

Circle #54 on page 51.

Air-Cooled Shaft For High Temp. Fans

Purpose: A unique air-cooled shaft eliminates the need for complex cooling devices in high temperature fans.

Features: Designed to function under conditions of high speed, pressure and temperature, the shaft has an integral chamber-and-slot arrangement which reduces transmission of heat. As the shaft rotates, air is evacuated from the internal chamber through four slotted orifices, creating a heat transfer barrier which keeps the shaft cool at all vital bearing points.

Made of nickel chromium stain-

(Please turn to page 48)

Product of the Month

Dust-Free Way To Collect Dust From Dust Collectors!

What good does it do to spend hundreds of thousands of dollars on electrostatic precipitators, dust collectors, etc., if in handling the material collected, you create a dust problem all over again?

The solution to this problem of handling and mixing powdery materials, is a new "Continuous-flow" bulk material conditioner that provides dust-free handling of dry materials. It's made by the Johnson-March Corporation, and three standard models handle a wide range of capacities from 150 lbs./cu. ft./hr. to 150 tons/cu. ft./hr.

Materials that can be handled include fly ash, flue dusts, zinc dust, vanadium ore, vermiculite, flour (vitamin solution), powdered milk, bath salts, petroleum coke, limestone, cement kiln dust, coal, and grain dog food.

The new unit, called Verticone, provides dust-free bagging operations and loading and unloading from bins, silos, ships, trucks or rail cars and especially dust collector bins.

Dust is suppressed by adding a precisely controlled amount of moisture into the finely-divided material. This moisture contains a wetting agent, Compound MR, that gives controlled wetting of all surfaces of each particle, adds as little as 1 percent of moisture in the process.

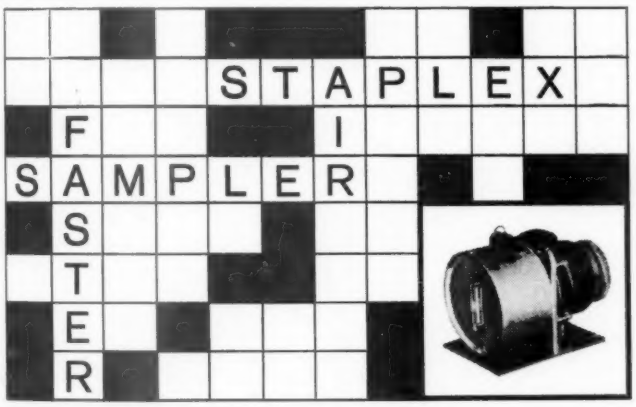
Rapid and effective conditioning is obtained by proper dispersion of the solid stream of the material. Material is introduced onto a distributing cone at the top of the Verticone. Materials fall over cone, leave base of cone in form of thin-walled (¼" to ⅜" thick) hollow cylinder.

Spray jet applies Compound MR so all surfaces of solids are properly conditioned and dust-free.

Internal blades prevent build-up inside Verticone.

The treated materials drop onto a retention plate at the base of the Verticone where final dispersion of the moisture takes place. A rotary table feeder discharges continuously to fit the flow of a materials handling system, or to rapidly load trucks or rail cars. The discharged material can be removed by conveyor, chute or other means as desired.

Circle #45 on page 51.



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2. smog, smoke abatement
3. beryllium dusts
4. mine inspection
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9. detection of any air pollutents

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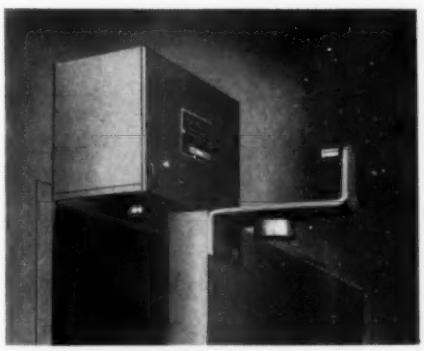

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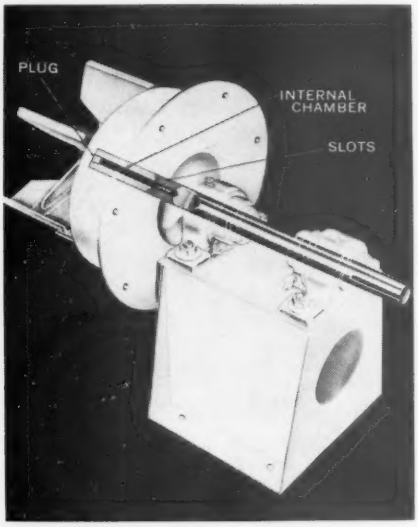
New PRODUCTS

(Continued from page 46)



less steel the air-cooled shaft is standard equipment on the company's entire line of Thermal-Aire fans for operating temperatures up to 1700°F.

Source: Garden City Fan & Blower Co., Niles, Mich.

Circle #55 on page 51.

Bureau Of Mines Approves New Respirator

Purpose: For protection against sprays and vapors of enamels, lacquers and lead based paints.

Features: The respirator consists of a rubber face piece covering the nose and mouth and two chemical cartridges. The cartridges contain pre-filters to catch particles and an inner unit to filter out fumes and vapors. Any of 16

types of cartridges may be used in the basic face piece, which also may be purchased with or without goggles.

Source: American Optical Co., Southbridge, Mass.

Circle #56 on page 51.

New Sprayed Coil, Draw-Thru "Climate Changer"

Purpose: To reduce installation time and simplify maintenance by internal factory insulation of the entire unit, including the tank section. Spray pump and piping, including gate valve and pressure gage, are also factory mounted.

Features: Spray action, float operation and the condition of the coils may be checked through unbreakable windows on both sides of the unit. Access is gained through removable panels.

Wide angle nozzles, an exclusive S-shaped coil fin configuration, and an "anti-air bypass" coil casing, make moisture eliminators unnecessary, according to Trane.

Sprayed coil "Climate Changers" operate at coil face velocities as high as 600 fpm without moisture carry-over.

Source: Trane Co., La Crosse, Wisconsin.

Circle #57 on page 51.

Benches For White Room Use

Purpose: A complete line of benches designed especially for white room use.

Features: Included in the line are wall mounted and pedestal based models, or double and single units designed with service outlets. All models are designed for minimum maintenance requirements.

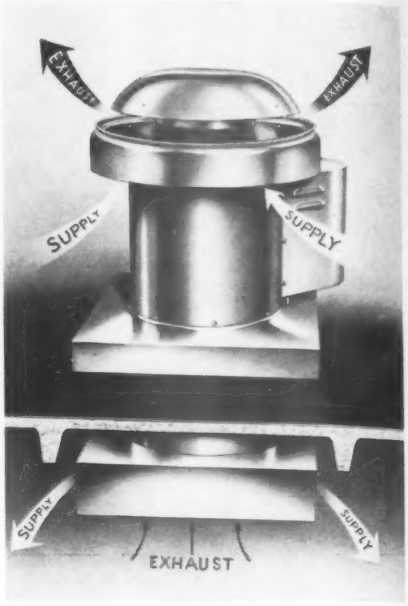
Source: Baker Instruments, Inc., Chandler, Arizona.

Circle #58 on page 51.

Ventilator To Provide Supply And Exhaust

Purpose: A compact single impeller in a package type unit to provide both supply and exhaust simultaneously.

Features: A single cast aluminum wheel is used. The outer annular portion of the wheel circulates the air in the opposite direction to that circulated by the inner portion of the wheel. Only one opening is necessary. The simplicity of the Twinalator cuts installation and maintenance time and cost. Available accessories for the Twinalator are (1) Adjustable diffusers. (2) Tempering coil cartridges for attachment to diffuser. (3) Motor disconnect switch. (4) Supply air filter.



Source: Clarage Fan Co., Kalamazoo, Mich.

Circle #59 on page 51.

Fume Controlled Chromium Plating Compounds

Purpose: Automatic control of fumes and spray that escape from chromium plating solutions.

Features: Supplied in pelletized form, Unichrome is a self-regulating, high-speed, low cost, compound used to reduce chromic acid loss and minimize loss of heat from the plating plants.

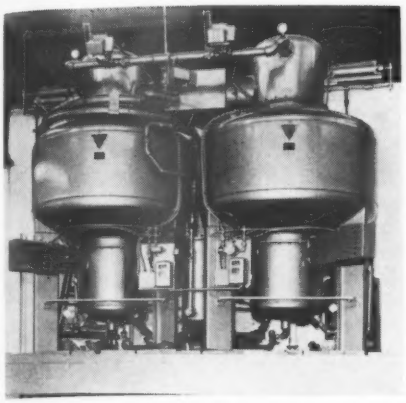
Source: Metal & Thermit Corp., Rahway, N. J.

Circle #60 on page 51.

New Solvent Vapor Recovery System

Purpose: A patented process for the recovery of usable solvent from vapors during degreasing and cleaning operations.

Features: Vic's Vapor Recovery System captures solvents by ducting them into a specially designed



tank with a bed of activated carbon and a steaming and decantering process, returning the solvents ready for reuse.

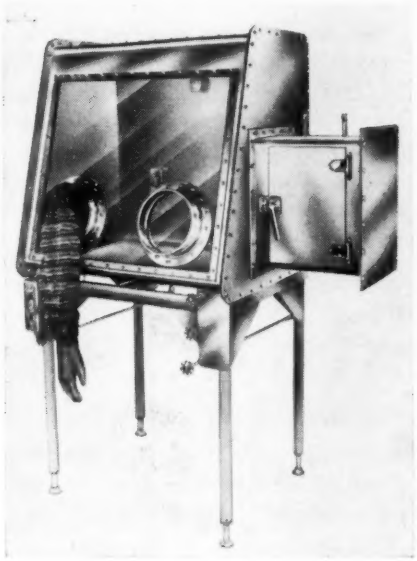
Source: Vic Manufacturing Co., Minneapolis, Minnesota.

Circle #61 on page 51.

Laboratory Safety Enclosures

Purpose: Visibility of the entire working area is offered for handling radioactive or other hazardous materials.

Features: The enclosures are designed for single unit installation or multiple-interconnected systems with 15° sloping fronts constructed entirely of safety plate glass. The interior work area has been enlarged and glove ports are located for greater interior



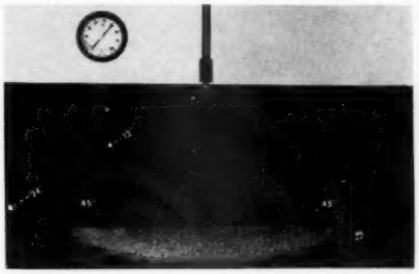
manipulation. Five types of enclosure are available: (1) Low intensity dry box. (2) Controlled temperature enclosure. (3) Microbiological safety enclosures. (4) Super dry boxes. (5) Stainless steel fume hoods.

Source: S. Blickman, Inc., Weehawken, N. J.

Circle #62 on page 51.

Solid-Cone Atomizing Nozzle

Purpose: Fig. 661-S Atomizing Nozzle produces a very fine, uni-



formly-atomized, solid-cone mist in capacities as high as 330 gph.

Features: They are available in bronze and stainless steel, in orifice sizes from 2.0 to 6.0 mm. Special corrosion-resistant materials are also available on request.

Source: Schutte and Koerting Co., Bucks County, Pa.

Circle #63 on page 51.

(Please turn to following page)

FOR 99 PLUS % EFFICIENT CORROSIVE FUME REMOVAL and MAINTENANCE FREE OPERATION

CARPART (TYPE CF) FUME SCRUBBERS

500 cfm to 40,000 cfm Capacities

efficiencies on:
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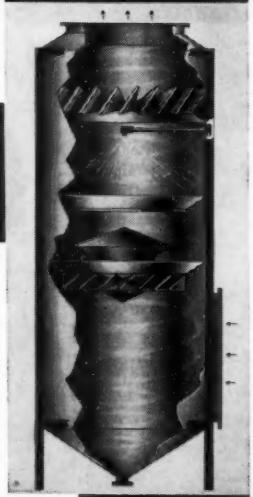
- SULFURIC ACID 99.4% to 99.5%
- BRIGHT DIP MIX 99.8% to 99.9%



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Effectiveness due to combination of 4 stage water curtain with baffled impingement and continuous centrafugal heavy particle separation.

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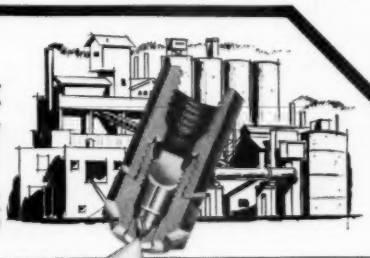

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hollow cone spray pattern

plus GENERAL DUST CONTROL

HIGH EFFICIENCY spray nozzles that operate on hydraulic pressure alone and low water volume per hour. Provide even pattern distribution and excellent atomization. Made in stainless steel and brass for maximum service. Proved for performance. Nozzles of all other types also supplied including pneumatic atomizing nozzles for every need.

SPRAYING SYSTEMS CO.

3202 Randolph Street • Bellwood, Illinois

FOR COMPLETE INFORMATION write for Catalog No. 24

New PRODUCTS

(Continued from preceding page)

Work Table For Clean Areas

Purpose: A new work table is available that is particularly adaptable where sanitary conditions, flexibility, and appearance are necessary.

Features: GP-100 tables come in 4 ft., 5 ft., and 6 ft. lengths. They are available with tops of formica, masonite, and glaze-weld that resists chemical stains, abrasion, and cigarette burns.

The table combines an interchangeable top and table leveler system with a rigid metal table frame virtually free of dust traps and is easily assembled.

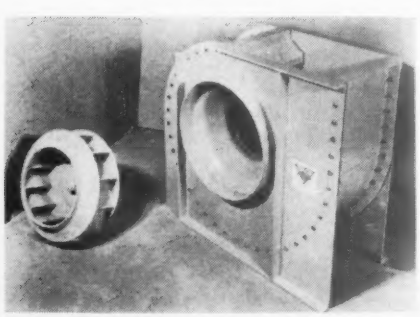
Accessories available are heavy duty industrial casters, metal drawers that slide on nylon rollers, and various combinations of shelving and mounting brackets for power and piping above or below the work surface.

Source: Leitch-Huard Corp., Manchester, N. H.

Circle #64 on page 51.

Reinforced Plastic Blower Housing and Fans

Purpose: The Duracor units can withstand extreme chemical resistance plus high strength/weight ratios, and may be installed as separate components or into integrally designed exhaust systems.



Features: The unit can handle chlorine fumes at temperatures up to 250°F at the rate of 12,000 cfm. Duracor housings and ducts are corrosion-proof throughout and a wide range of resins are formulated to meet individual operating requirements.

Source: The Ceilcote Co. Cleveland, Ohio.

Circle #65 on page 51.

Portable Hi-Volume Air Sampler

Purpose: To sample large volumes of air for particulate matter by means of a filter pickup.

Features: The unit employs a turbine-type blower principle and

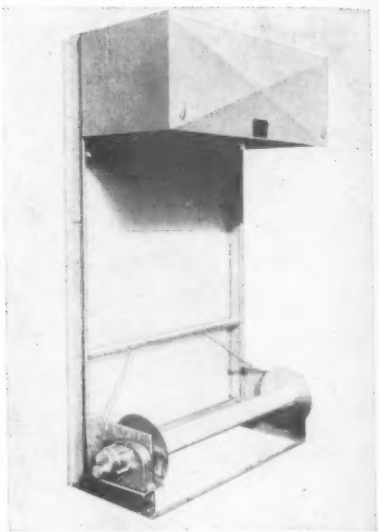
can sample air particles 1/100th of a micron in diameter. Manufactured from cast aluminum to reduce weight, it may be used indoors or outdoors. The sampler is designed for 24-hour sampling with a 49 hp heavy duty pump and a 15,600 rpm high-speed motor.

Source: Staplex Co., Brooklyn, N. Y.

Circle #66 on page 51.

New Roll Type Air Filter

Purpose: The new Farr V-7 Roll-Kleen Air Filter operates on the same principle as the film roll



in a box-type camera. The filtering media comes in a roll, unwinds from the top, passes downward and is rewound on a bottom spool. Used filter rolls are disposable.

Features: When pressure drop reaches the pre-set limit, a switch actuates the mechanism that advances the media. The V-7 media roll consists of a glass filter material 65 ft. in length. It has a high dust-holding capacity with an efficiency above 81 per cent, and operates best between a velocity range of 350 to 500 fpm.

Source: Farr Co., Los Angeles 45, Cal.

Circle #67 on page 51.

Extended Ventilator Bases

Purpose: Reduce air and motor noise of low silhouette hooded exhaust roof ventilators.

Features: Absorption insulation made of glass fiber. Can be used on flat, slanted or peaked surfaces.

Available in galvanized or aluminum units in sizes from 15 in. to 48 in. square.

Source: Western Engineering & Mfg. Co., Los Angeles 66, Calif.

Circle #68 on page 51.

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Chemical Engineers
Industrial Air Pollution Abatement
L. B. Hitchcock.....Edwin Cox
John H. Schaefer, Technical Advisor
60 East 42nd St., New York 17, N. Y.

Letters to the Editor

(Continued from page 11)

to become reasonably involved in not only the formation of this Society, but would hope to serve at some time in various positions to aid in its aims and operations.

For many years we have expended reasonable sums of money, and at times, unreasonable amounts of enegry, in the pursuit of ultra-clean working areas. From both a scholastic and engineering standpoint we have expended a lot of effort trying to convince owners of the necessity of cleanliness, and the techniques to achieve same.

Unfortunately, we were not able to attend the White Room Symposium in Arizona, however, we understand that another meeting will take place in Grand Rapids, Michigan during the summer months, and you may rest assured of our attendance, and our willingness to assist in the planning and work for this meeting in whatever capacity one might choose.

I wish that you would place this letter at the disposal of the Executive Committee of ASCCA and consider it as an invitation to assist in whatever way would seem best and proper to them.

G. T. Saunders
Manager
Kewaunee Scientific Equipment
Adrian, Michigan

Note: Anyone interested in the ASCCA, please contact, Editor, AIR ENGINEERING.

Industrial Hygiene News

(Continued from page 19)

drainlines has increased the hazard of lead poisoning since large quantities are melted and poured to seal joints in lines to solder sections of copper pipe.

● Reusable concrete forms which have become standard in the past years, are usually constructed of plywood and must be sprayed with oil to aid in separating the form from the concrete, creating exposure to oil mists.

● Gasoline-powered cement-finishing machines create exposures to noise, carbon monoxide, and products of combustion.

the Q's and A's of

AIR ENGINEERING

Q THE PROFESSION: ***What is air engineering? What does it mean to you?***

A Air engineering is the art and science of making air comfortable, healthful, safe, and useful for people, products, and processes.

Q THE MAN: ***Who is the Air Engineer? What does he do?***

A He is a member of an increasingly vital profession. He deals with problems of air. He is involved wherever combustion, chemical or mechanical processes or natural causes create smoke, dust, heat, cold, fumes or odors hazardous or annoying to personnel or the community or damaging to property or products. Air Engineers as a group are men of many titles. The Air Engineer may be any one of these . . .

- an *engineer or executive* in an industrial plant or commercial establishment, a utility or an institution in which his primary function is the handling and treatment of air.
- *an industrial hygienist* concerned with the reduction of airborne hazards to the health of personnel.
- *a registered consulting engineer or architect* concentrating on the problems of air in new or existing facilities.
- *a mechanical contractor* specializing in air handling installations.
- *a Government authority* cooperating with industry to effect compliance with codes and regulations governing the purification of air.

Q THE MAGAZINE: ***How does it serve the profession?***

A *AIR ENGINEERING* is the *only* practical magazine dedicated to helping the Air Engineer fulfill his vitally important mission of creating pure air environment.

AIR ENGINEERING'S editorial objectives are, in brief: 1) to give readers up-to-date, practical working information useful in coping with air problems and 2) to bring together in closer communication fields and industries concerned with the handling and treatment of air.

Another, and valuable function of *AIR ENGINEERING* is to help you, the manufacturer, move equipment and materials in this important, dynamically-developing field.

Air Engineers *specify, recommend, select and purchase* a wide array of products having to do with AIR MOVING, AIR CONDITIONING and AIR PURIFICATION. If your product relates to one or more of these functions, your advertising in *AIR ENGINEERING* will be closely read by an interested, receptive audience of more than . . .

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